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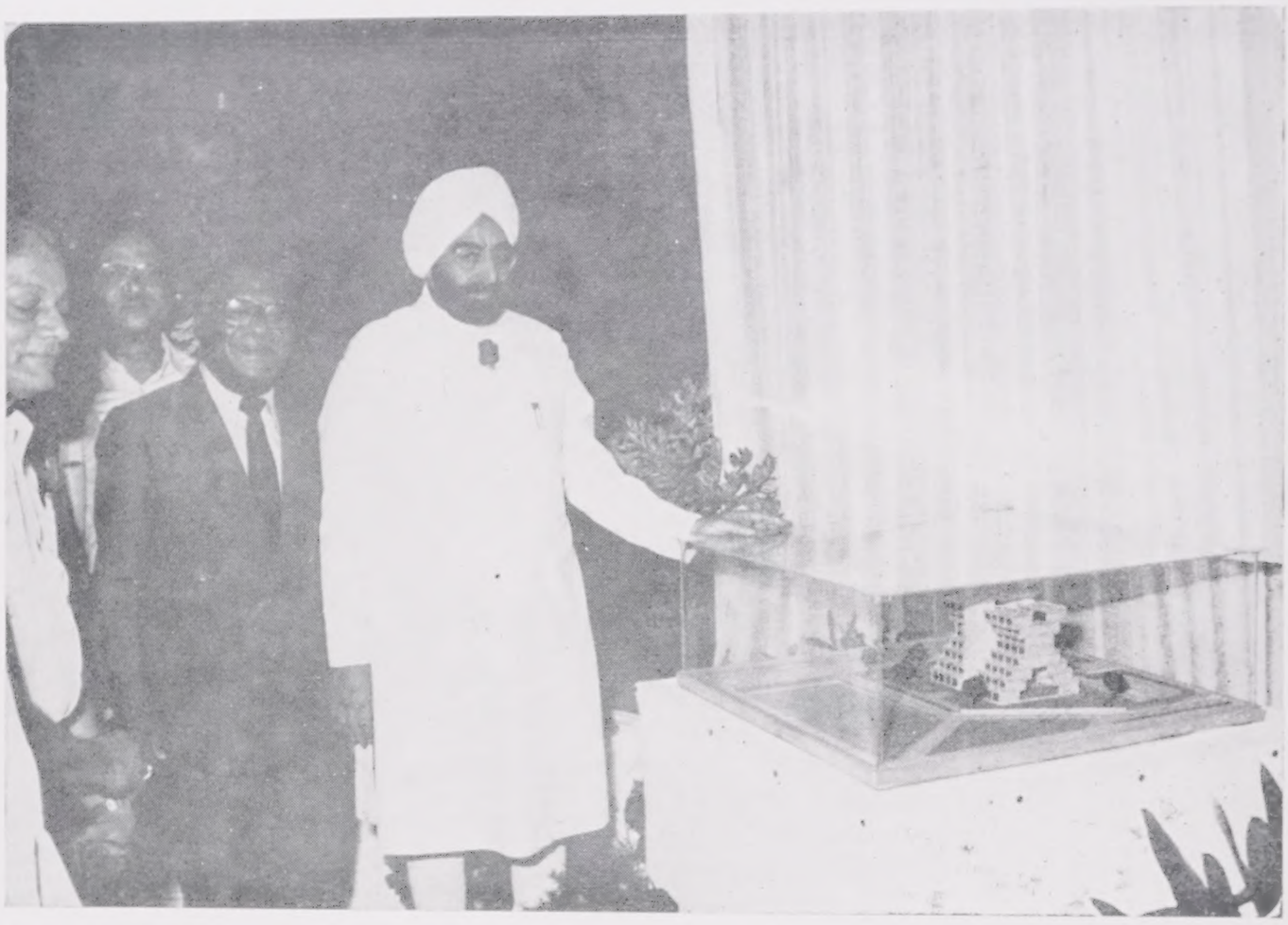
The President of India, Giani Zail Singh, releasing two prestigious INSA Golden Jubilee publications 'Science In India: 50 years of the Academy' and 'Niels Bohr—A Profile'.

INDIAN NATIONAL SCIENCE ACADEMY NEW DELHI



Giani Zail Singh, Professor CNR Rao and Professor S K Joshi alongwith the model of new INSA building.

September 30, 1985 was a memorable day in the Academy. The foundation stone of the new Academy building was laid by Giani Zail Singh, the President of Indian Republic. The new building will come up adjacent to the present one in the same complex on Bahadur Shah Zafar Marg. The President also released two prestigious INSA Golden Jubilee publications 'Science In India : 50 years of the Academy' and 'Niels Bohr—A Profile'. Speaking on that occassion, the President lauded the role played by the Academy and the Fellowship in the growth and development of the country. He also expressed the hope that the Academy will continue to guide the scientific community at large in the matters of national relevance.

Earlier, the same day, the Academy organized a seminar 'Issues in Higher Education in Science' under the Chairmanship of Professor C N R Rao. Small group of peers pondered for few grilling hours and came up with specific recommendations in each broad area of scientific education. These recommendations were sent to the policy planners as Academy's views on Science Education in our country.

BOHR AND DIRAC

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I am thankful to Professor C N R Rao for inviting me to speak to such a distinguished audience on the lives and accomplishments of Niels Bohr and Paul Dirac. This talk was in fact commissioned by him, and the title too was his choice, much as a patron of the arts might commission a painting from an artist. Let me hope that the portraits that I will paint of these two great figures from the world of physics will be faithful to the originals.

It is particularly appropriate that we speak of Bohr and Dirac at this time. 1985 is the centenary year of Bohr's birth, while Dirac passed away only recently in October of last year.** There was a gap of almost a generation between them—Bohr being born on October 7, 1885, and Dirac on August 8, 1902. Let us also recall that Einstein spanned the period 1879 to 1955; so he was just six years older than Bohr, and stayed that way.

For both Bohr and Dirac, the most important work of their lives was bound up with the strange story of the quantum—the struggle to adapt and alter the fabric of classical physics to accommodate Planck's quantum of action. It turned out that this called for an overhauling of all three components of the classical scheme—matter, motion and radiation. Naturally Bohr appeared on the scene at an earlier phase of the struggle than did Dirac, and several others were also involved, but today our focus is on these two.

Some of you may remember that Planck made his momentous discovery sometime in the evening of sunday, October 7, 1900 (incidentally, Bohr's fifteenth birthday). The experimental physicist Heinrich Rubens and his wife had visited the Plancks for tea that afternoon. Rubens told Planck of his and Kurlbaum's measurements of the black body radiation spectrum in the far infrared limit, where he had found definite deviations from the Wien radiation law. This law was a theoretical one which had been proposed in 1896, by Wien, and which Planck had believed to be exactly valid. Soon after the Rubens left, Planck set to work to find an interpolation between Wien's Law, known to be valid at high frequencies, and the low frequency measurements just reported to him by Rubens, which incidentally agreed with the theoretical results of Rayleigh and Jeans. It was thus that Planck arrived at his celebrated radiation law. It is somewhat staggering to realise that quantum theory was born or discovered in this way in the space of a few hours! It is also a hint to us professors that we really ought to invite each other over for tea, with our spouses, more often than we do, and to talk about our scientific work rather than other matters. The quantum of action was thus first discovered *via* the thermodynamic properties of light, and in the succeeding years the first insights into its significance came largely through statistical arguments as well as the wave-particle duality of light. In all of this, of course, Einstein played a leading role. However, the connection of Planck's discovery to the structure of matter, its stability and its mechanics had to wait for Bohr's magic touch in the years 1912–13.

During his doctoral work on the electron theory of metals, completed in 1911, Bohr had realised very clearly that there was a need for a radical departure from the laws of classical electrodynamics in the atomic domain. It was extremely fortunate for him that in March 1912 he went to work briefly with Rutherford at Manchester, after a disappointing stint with J J Thomson at Cambridge. At Manchester he came to know of Rutherford's model of the atom in which the positively charged core of the atom, the nucleus containing practically all the mass, occupied a practically negligible volume at the centre of the atom. This was in contrast to Thomson's model in which the positive charge was spread out uniformly over a finite volume of atomic dimensions. Many problems and possiblities immediately became clear to Bohr. On the one hand, in order to produce in this model a length scale of the order of the atomic size, and also to ensure stability of the electron orbits, it was essential to bring in Planck's constant. On the other hand, it now appeared that all the chemical properties of an element should depend only on one datum, namely the number of peripheral electrons, i.e. the atomic number rather than the mass number. In fact, Bohr saw that while

*Talk delivered by N. Mukunda, FNA at the Ordinary General Body Meeting of INSA held at the Indian Institute of Science, Bangalore on 2 August, 1985.

**Niels Henrik David Bohr, b. October 7, 1985; d. November 1962.
Paul Adrien Maurice Dirac, b. August 8, 1902; d. October 1984.

chemistry was determined by the outermost electrons of the atom, all radioactive processes like α and β emission originated from the nucleus, deep inside the atom. It appears that at this stage Bohr took Rutherford's model more seriously than Rutherford himself!

Turning to the structure of the atom, Bohr took over Thomson's picture and assumed that the electrons moved in concentric circular rings around the nucleus. Classical electrodynamics could never explain the stability of such as arrangement; but Bohr had already anticipated the need for a fundamental departure from classical ideas in this realm. He was familiar with Planck's method of quantizing the motion and the energy of simple harmonic motion, and he now adapted it to the motion of an electron in the Coulomb field of the nucleus. As much by inspiration as by deduction he was able to arrive at the right order of magnitude for atomic sizes, and at the expression $E_n = -A/n^2$ for the allowed energies of an electron bound in an atom. Here the integer n takes values 1,2,3... For all of this of course, Planck's constant was essential, but as yet the exact form of the quantum condition was beyond him.

At this stage another important event occurred—he was called upon to investigate the passage of α-particles through matter and analyse the processes by which they ionized the atoms of matter, losing energy and slowing down as they did so. This was a matter of practical importance in Rutherford's laboratory. The fact that he could give a satisfactory classical account of this process, whereas classical ideas failed completely within the atom, led him to the following truth : however deep the break with classical ideas might be, the new theory would have to agree with the old one in the limit of low frequencies or large quantum numbers. This was the origin of the famous Correspondence Principle, which played such a major part in subsequent developments.

At this point in his thinking Bohr had dealt only with structure and stability of the atom, and had not connected up with atomic spectroscopy or radiation phenomena. He returned from Manchester to Copenhagen in July 1912, married Margrethe Norlund in August 1912, and set about writing up the ideas conceived in Manchester. It was only in early 1913 that his mind suddenly turned to problems of atomic radiation. Atomic spectroscopy was a well-developed field with a lot of data on the characteristic spectral lines and frequencies associated with various elements. There also existed several empirical formulae giving simple expressions for many series of spectral lines. H M Hansen, a colleague of Bohr's at the University of Copenhagen, asked him in early 1913 if he knew of Rydberg's formula which expressed every frequency as the difference of two terms, and which for hydrogen took the simple form

$$\nu_{mn} = R\left(\frac{1}{n^2} - \frac{1}{m^2}\right),$$

where both n and m were integers. Bohr had not known this even though it had been around since 1890, and Rydberg worked at the nearby University of Lund in Southern Sweden. So this query and information from Hansen came as a complete surprise to Bohr. But at the same time he saw that it gave the missing clue to the problem of quantization in the atom. He compared his own formula $E_n = -A/n^2$ for quantized electron energies in an atom with individual terms in Rydberg's expression and immediately realised that each spectral line corresponded to a transition of an electron from one allowed state to another, accompanied by emission of a quantum radiation. In the Planck-Einstein spirit, it was Bohr who first saw the Rydberg law as an expression of the conservation of energy,

$$h\nu_{mn} = E_m - E_n, \quad E_m = -h\,R/m^2$$

By demanding agreement with classical theory for large n, Bohr was able to pin down completely the quantization condition as well as calculate the value of Rydberg's constant. The break with classical physics came with the fact that none of the spectral frequencies ν_{mn} coincided with any of the classical orbital frequencies, but such a break was essential to explain the stability of the atom, as anticipated by Bohr. In fact he said that Rydberg's formula gave him such a transparent clue that he saw immediately the quantum picture of the emission of radiation. He was sure he was on the right track in spite of the total breakdown of classical physics; at the same time the Correspondence Principle was obeyed.

In 1913, he published his three famous papers on the constitution of atoms and molecules. Here he stated his two fundamental postulates : (1) the electron could only be in one of a special set of stationary states which had to be chosen out of all possible classical motions by imposing quantum conditions; (2) the transition of the electron from one to another such state is a non classical and nonvisualizable process, during which a single quantum of radiation is emitted or absorbed according to the Rydberg-Bohr frequency condition.

Many predictions of Bohr's theory were checked in Rutherford's laboratory, but the English physicists, in particular Fowler and Jeans were sceptical and accepted his ideas only reluctantly. It seems that in Gottingen there was a sense of scandal and bewilderment. But both Einstein and Sommerfeld saw immediately the significance of Bohr's ideas.

I have spent a considerable amount of time recounting this early phase of Bohr's work because it was the foundation of all else that followed. Indeed though the quantum of action was discovered in the properties of radiation, the route to the new quantum mechanics was via the mechanics of the atom; and the application of Planck's idea to the dynamics of matter, which Dirac was to later describe as the most difficult first step, was taken by Bohr.

Bohr was fully aware of the limitations of his

theory. It was necessary to generalise the quantum condition from circular motions of a single particle to motions of a general mechanical system; to analyse the relationship between classical and quantum aspects of atomic phenomena; and to explore the many applications of his theory. To do all this he gradually built up a school around himself in Copenhagen. One of his earliest collaborators was Kramers from Holland, who joined him in 1916. By 1919, he had an Institute of his own. Meanwhile his programme had been taken up also by the groups at Gottingen and Munich, led respectively by Max Born and Sommerfeld. The three centres worked in an atmosphere of friendly cooperation with frequent exchanges of ideas, and sharing of successes, hopes and people. Pauli and Heisenberg, among others, travelled frequently from one of these centres to another. In 1915, Sommerfeld found the general form of the quantum conditions for any so-called multiply—periodic system, and soon Bohr adopted Sommerfeld's mathematical methods. Instead of a picture of electrons moving in concentric circular orbits in a plane, Bohr could now deal with shells of electron orbits, tackle complex atoms and their spectra, and go on to elucidate the structure of the periodic table. This was of course a great shot in the arm for chemistry. One must remember that Bohr did all this before the Pauli exclusion principle and the electron spin had been discovered. In all this work the Correspondence Principle was the constant guide, being used both brilliantly and judiciously. In 1921, the Correspondence Principle was extended to dispersion by Ladenburg, and Kramers followed this up in Copenhagen. In this work he was joined by Heisenberg. (Along the way Bohr collected the Nobel Prize for 1922.) But not all the data could be satisfactorily explained by the theory. Bohr remained acutely aware how far he was from a logically consistent framework able to explain his two postulates and in harmony with the Correspondence Principle. In fact, the period 1923-25 witnessed a crisis in the old quantum theory. To this period belongs a famous paper of Bohr, Kramers and Slater. Here Bohr tried to give an overall picture of radiative processes taking place in the atom, and the authors suggested that classical causality had to be replaced by a purely statistical description. This paper had a deep influence on Heisenberg, as it showed ever more clearly the inadequacy of the classical picture of atomic processes.

As is well known, the resolution of the crisis came with Heisenberg's discovery of matrix mechanics in June-July 1925. This was a direct outgrowth of his work with Kramers in Copenhagen on dispersion, and of the influence on him of the Bohr-Kramers-Slater work. But all that is another story.

Meanwhile, back at the ranch in Cambridge, a young Paul Dirac had joined RH Fowler as a research student in 1923, after getting a degree in electrical engineering. For two years he worked on applying Hamiltonian methods to multiply periodic systems in the framework of the Rutherford—Boher model, but that did not lead to any significant successes. Then in September 1925 his lucky break came when by a somewhat round about route he learnt of Heisenberg's discovery of matrix mechanics. This was the spark that ignited him. He soon elaborated, practically in isolation, his own version of quantum mechanics, giving it a particularly abstract and elegant structure. One might remember here that Heisenberg's achievement had been aided by continuous contact and exchange of ideas with Bohr. Born, Pauli, Kramers and Sommerfeld. In any case once the key step had been taken by Heisenberg, progress towards the establishment of a mathematically satisfactory quantum mechanics was extremely rapid and was essentially finished by early 1927. Schrödinger's discovery of wave mechanics had come in early 1926, and its equivalence to Heisenberg's version soon after. One of Dirac's key contributions in this phase was the exposure of the link between classical and quantum mechanics. This was the most beautiful expression of the Correspondence Principle and, said Dirac, it had given him maximum pleasure of all his discoveries.

From 1925 to 1927 the most important advances were being made by Dirac in Cambridge, Heisenberg, Born and Jordan in Gottingen, and Schrödinger in Zurich. During this period Bohr was in a sense watching from a distance, with a critical but approving attitude. He had inspired and oriented the work of the others; and the new theory had attained the goals he had set himself all along. The departure from classical physics he had sensed and foreseen for so long was now precisely expressesd: relations among physical quantities could no longer be maintained in the classical numerical sense but only in a more abstract algebraic sense. Every physical attribute of a system could not at all times be reduced to a number. When the stage was set to find the physical meaning of the mathematical structure, Bohr reentered the scene. The deeper understanding of the situation needed Bohr and his philosophical bent of mind. Indeed Heisenberg said of him: "Bohr was primarily a philosopher, not a physicist, but he understood that natural philosophy, in our day and age carries weight only if its every detail can be subjected to the inexorable test of experiment." In early 1927, between the two of them, Bohr and Heisenberg developed what we now call the Copenhagen interpretation of quantum mechanics. In this, they were greatly aided by the transformation theory of quantum mechanics, which had just been developed by Dirac and Jordan. Heisenberg's contribution was the uncertainty relations. Bohr's was the complementarity idea. According to the latter, every classical concept retains its usefulness in quantum mechanics, but not necessarily all of them simultaneously. According to Bohr, this was the greatest lesson of quantum mechanics: that the classical concepts, each individually valid, might be mutually exclusive. In later years, he would say

that physics had by its simplicity shown the way to this profound idea, but that the idea itself was applicable to much more complex situations, such as the relation between physics and life.

Einstein critically attacked the Copenhagen interpretation at the two Solvay Congresses of 1927 and 1930, and it was Bohr who each time answered him and proved the logical consistency of quantum mechanics. Finally, Einstein had to concede, saying only that he still felt there was an unreasonableness about it all. Of Bohr himself he said: "His is a first-rate mind, extremely critical and far-seeing, which never loses track of the grand design; he is truly a man of genius. It is fortunate to have someone like that."

Turning our attention now to Dirac for a while, I have already told you how he burst on the scene in late 1925. Thereafter, he kept going like a house on fire, with a steady and staggering profusion of fundamental ideas and discoveries. One of his most important papers, on the quantum theory of the emission and absorption of radiation, was written at Bohr's Institute in Copenhagen; so he too had been drawn into the Bohr circle. By applying the principles of quantum mechanics to the electromagnetic field, Dirac brought to a successful conclusion the work begun by Planck in 1900, and also inaugurated the quantum field theory. Then there was the discovery of the new statistics named after him and Fermi; the relativistic theory of the electron; the prediction of the positron and the general concept of antimatter; the idea of the magnetic monopole; and so many more. In the midst of all this, he wrote the classic book *The Principles of Quantum Mechanics* often compared with Newton's *Principia*. It would take far more time than I now have to speak with justice of all that Dirac accomplished in this period. Just as Bohr had made the preceding era a heroic one, Dirac turned this one into the Golden Age of Theoretical Physics.

There is a charming anecdote from the Solvay Congress of 1927 which is worth recalling. In the interval between two sessions Bohr asked Dirac what he was working on, to which Dirac replied that he was looking for a satisfactory relativistic wave equation for the electron which would combine special relativity and quantum mechanics properly. Bohr then told him that such an equation had already been found by Klein and Gordon, but before Dirac could explain why he was not satisfied with it the bell rang and they had to go back to the sessions. Dirac later said: "...it rather opened my eyes to the fact that so many physicists were quite complacent with a theory which involved a radical departure from some of the basic laws of quantum mechanics, and they did not feel the necessity of keeping to these basic laws in the way that I felt."

Dirac's style is essentially mathematical, and he turned out to be a master craftsman in the art of theoretical physics. He created with ease the mathematical tools that he needed. Bohr on the other hand was somewhat like Faraday. As Heisenberg said: *...his insight into the structure of the theory was not a result of a mathematical analysis of the basic assumptions, but rather of an intense occupation with the actual phenomena, such that it was possible for him to sense the relationship intuitively rather than derive them formally.* For Dirac, considerations of mathematical beauty and symmetry were of the highest importance, and he was supreme in the art of manipulating and working with the abstract. Bohr on the other hand was much more concerned with the problems of interpretation and communication, the difficulties and ambiguities inherent in language, and such philosophical questions.

Dirac's writings have a characteristic and unmistakable directness, simplicity and beauty. Bohr on the other hand is much harder to read because each long sentence of his contains a great deal of thought in compressed form. He spent a lot of effort in the choice of each important word. Bohr's style of work was to have a junior collaborator sit at a desk and take down notes while he himself kept pacing up and down the room, forming and changing and reforming his phrases and sentences. Watching him at one such session, Dirac apparently said something to the following effect: "Professor Bohr, when we were young we were taught never to start a sentence until we knew how to finish it."

Bohr's speech and hand writing were, respectively, inaudible and illegible. On both counts, Dirac was far superior. As Bohr himself said: "Whenever Dirac sends me a manuscript, the writing is so neat and free of corrections that merely looking at it is an aesthetic pleasure. If I suggest even minor changes, Paul becomes unhappy and generally changes nothing at all."

As I recalled earlier, Bohr was very deeply interested in the problems of biology, which he saw as a fertile field of application of his Principle of Complementarity. In fact for him physics was a far simpler problem. In Dirac's writings I have been able to find a reference to biology. In his paper of 1931 concerned with the magnetic monopole, he says: "There are at present fundamental problems in theoretical physics awaiting solution, e.g., the relativistic formulation of quantum mechanics and the nature of atomic nuclei (to be followed by more difficult ones such as the problem of life)..." At another time he is supposed to have said that his equation for the electron explained all of chemistry and most of physics. Presumably for him the problem of life was just one more of the things that theoretical physics would deal with in good time!

Bohr created and inspired an international school of theoretical physics; and his influence upon others was as much by direct contact and involvement in their struggles as through his writings. Dirac on the other hand worked much

more on his own. He did not create a school of any kind, though his influence on others through his writings and ideas has been enormous.

In the years following the creation and completion of quantum mechanics, Bohr turned to the problems of nuclear physics while Dirac was more concerned with relativistic quantum field theory and later on with gravitation and cosmology as well. However, there is a classic contribution by Bohr along with Rosenfeld in 1933 to quantum field theory. They analysed the consistency of applying the principles of quantization to the electromagnetic field—something which Dirac had done in 1927—and demonstrated the logical necessity of doing this if the quantum mechanics of particles and in particular Heisenberg's uncertainty relations were to be upheld.

As human beings there is a great deal worthy of admiration in both Bohr and Dirac, and a touching simplicity and sincere modesty in their dealings with others. Dirac was always most ready to acknowledge his debt to others. And in seminars it seems that Bohr would always preface his questions with the statement that he only wished to understand better the speaker's point of view. Bohr did concern himself with political matters and spoke a great deal on philosophical issues as well, while Dirac seems to have avoided both areas. Bohr was quite categorical that quantum mechanics was complete; and the most valuable lesson it had taught us was that of complementarity. He was anxious to extend its application to other fields such as reason and instinct, heredity and environment, physics and biology. His debate with Einstein, begun in the 1927 Solvay Congress, continued for more than two decades, and he maintained his point of view. In the 70's however, Dirac had this to say: "...the present form of quantum mechanics should not be considered as the final form... It is the best that one can do uptill now. But one should not suppose that it will survive indefinitely into the future. And I think that it is quite likely that at some future time we may get an improved quantum mechanics in which there will be a return to determinism and which will, therefore, justify the Einstein point of view." One is left speculating what Dirac had in mind.

Physicists are familiar with many lovely sayings and stories about and by Bohr and Dirac. And they are all really a reflection of their greatness as human beings. Bohr was ever a synthesizer of conflicting points of view and a philosopher at heart. On one occasion he said: *The opposite of a correct statement is a false statement. But the opposite of a profound truth may well be another profound truth.* On another occasion he is quoted as saying: "There are things that are so serious that you can only joke about them." One of Dirac's most celebrated statements was about the value of mathematical beauty in physics. He said: "... it is more important to have beauty in one's equations than to have them fit experiment... It seems that if one is working from the point of view of getting beauty in one's equations, and if one has really a sound insight, one is on a sure line of progress." This reminds us of the poet John Keats saying "What the imagination seizes as beauty must be truth—whether it existed before or not."

Bohr paved the way from the world of classical physics to the world of the quantum, guiding everybody through the most difficult period with his unerring instinct and intuition. And when the great victory had been won it was he who most comprehensively assessed the impact it had for the nature and goals of science. Dirac was one of the chief architects of the victory, and he then went on to raise theoretical physics to unparalleled heights of imagination and beauty. As much for their heroic labours as for their great human qualities, Bohr and Dirac will always rank among the greatest scientists of all time.

India's first tissue bank will be established at Institute of Nuclear Medicine and Allied Sciences (INMAS), Delhi with the help of International Atomic Energy Agency and World Health Organization. The Tissue Bank will preserve and store skin dressings, bone grafts, nerves and blood vessel grafts etc.

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FOOD AND ENVIRONMENT*

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It is appropriate to start with reference to the ethos of food as accepted in the post-vedic age in India. *Caraka* describes the basic attributes of food or *Ahara* in his Sutra 28:

आहारसम्भवं वस्तु रोगश्चाहारसम्भवाः ।
हिताहितविशेषाष्च विशेषः सुखदुःखयोः ।।
Caraka-Sutra 28 : 45

Aharasambhavam Vasthu Rogaschaharasambhavah
Hithahithaviseshascha Viseshah Sukhadukhayoh

In substance, what is meant by Caraka is: the material well being of man is the end-product of food, so are the diseases. All the good and evil, the desirable and the undesirable and the special features of the body, the well being and the ill feeling all arise out of food.

To appreciate the relevance of the above definition to the theme of my lecture today, we must analyse the derivation of the words *Sarira, Deha* and *Kaya* used in ancient Indian medical literature to refer to the human body. The deployment of roots and words derived from them could not have been used with greater precision and perfection. Thus *Sarira* is *Sru-Iran-Sreeyate Anena Iti Sareeram*-i.e. to be rendered to pieces. *Deha* is derived from the root *Dih* to grow or to develop. *Kaya* is a combination of the functions implied in *Sarira* and *Deha*, namely, disintegration and integration or to use the language of biochemistry, *Sarira* envisages the function of catabolism, *Deha*, envisages the function of anabolism and *Kaya* envisages the steady state of homeostasis, the balance between catabolism and anabolism which sustains health.

By all evidence we have today, we know that homeostasis is sustained by the food we ingest. Since food comes to us from the external environment to be processed and assimilated in the internal environment to enable us to respond to external stresses of the body, the connection between food and environment is not accidental. In today's presentation when I talk of the environment, I refer to the biosphere and its life-support systems.

Agriculture and Civilization

Air, water and land constitute the main components of our environment. The interlinks of these three for food production are obvious. In the cycling of the four important elements of the body–carbon, hydrogen, oxygen and nitrogen the three compartments interact and make it possible for an ecological equilibrium to prevail on the basis of a food web or food chain. Photosynthesis, nitrogen fixation and denitrification are processess which proceed with amazing precision essential for the evolutionary transformation of life in the biosphere.

Agriculture was the first turning point in human history. Hunters and nomadic tribes had to retreat to bushes and places not wanted by others—the African bush, the Australian outback, the Arctic regions of America, Siberia, etc. The hunters and herdsmen who became the nuclei for our own tribal clusters left nature largely undisturbed. With the arrival on the scene of their successors, the peasants, began the history of human intervention with nature and natural ecosystem. That was the price civilization had to pay then, very much as environmental pollution is considered as the price we have to pay today for industrial development.

With agriculture emerged husbandry, dairying and fishing. Human beings learnt the art of using water and land for food production and understood instinctively the cardinal role of air in the equilibrium. Along with food, water was recognized as another essential need for life. Civilizations, therefore, flourished on the deltas and basins of the river valleys of the earth.

Composition of Food

The science of nutrition has taught us the properties and role of the essential components of our food, viz., proteins, fats, carbohydrates, minerals and vitamins. We are also familiar with what are called the FAO-WHO minimum requirements of calories and proteins for growth, lactation and other physiological activities. Our problem as well as the problem of most of the less developed countries is supposed to be one of protein-calorie malnutrition. No wonder the strategy

*Based on the talk delivered by C R Krishna Murti, FNA at National Museum of Natural History, New Delhi on 15 January 1983.

of planning for self-sufficiency in food is directed towards increasing the output of cereals. Let us remind ourselves of the impact of politics on the global food situation. Out of the total world production of cereals and pulses, 70% is consumed in the developed world mostly by animals. To be more precise out of the 125kg per capita consumption of cereals in the developed world, 90kg go to feed cattle, poultry and pigs. In the third world countries, in contrast, per capita consumption of cereals is less than 50kg and most of it is eaten by humans and hence the competition pressure between animals of the developed world and humans of the third world for foodgrains.

Since most of our food is derived from the interaction of environmental components, it is obvious that the composition of food can be profoundly affected by environmental quality. The traditional art of plant breeding or animal breeding have been enriched by modern biotechniques of plant and animal genetics. We have access today thus to a variety of procedures by which one could manipulate the composition of food and even pròduce tailor-made food articles. Food technology, based again on a mix of tradition and science, has revolùtionized the methods of post-harvest, storage, distribution, processing, etc. of food. We in this country have just entered into the era of food processing technology. Admittedly, most of the food we consume is still derived by conventional and traditional methods with some marginal evidence of the impact of processing technology on the consumption style of the elitist class. Fortunately, there is much of value in traditional methods and habits which are worthwhile to be preserved even as we change our way of living. At the same time there is much scope for incorporating the principles of modern nutrition and food science into our traditional dietary habits.

Hazards of Food

A list of common hazards of food is given in Table I. The first four, namely, microbiological, nutritional, environmental factors and natural toxicants originate from the interaction of the nature of the species which is the source of the food with environmental factors. Microbiological hazard owes its origin to the competition between lower forms of life like microorganisms and man for the same nutrients. The last two, viz., pesticide residues and food additives, arise out of the technology used today both in the pre-harvest and post-harvest phases of food production.

TABLE I. *Common hazards of foods*

a. Microbiological
b. Nutritional
c. Environmental
d. Natural toxicants
e. Pesticide residues
f. Food additives

Microbial Contamination

All plant based foods, cereals, pulses, oil seeds, constitute food for many lower organisms including bacteria, fungi, insects, rodents and other predators. The contamination of food by fungi and bacteria has attracted much attention because of the fact that these living forms while multiplying on food grains excrete into the environment very powerful poisons. Some of the known mycotoxins, toxins produced by mycelia-forming fungi are enumerated in Table II. Of these, aflatoxins are of global significance. They are of great relevance to our economy since the countries which import plant based materials from India have been imposing ever growing restrictions on our export commodities because of their unacceptable levels of aflatoxins.

The predecessors of those who live today in the Coromandel coast of India in Orissa, the Andhra coast and Tamil Nadu were aware of the perils of fungal contamination of paddy without knowing anything about aflatoxins. It is just enough to remember that the technique of parboiling of paddy was known to the contemporaries of the Sangam age of South India. Parboiling was done presumably to preserve the paddy and in a way protect it from microbial and insect infestation.

How bacterial infection can affect food and water and cause ill-health is evident from examples given in Table III. Microbiological studies have revealed that temperature and acid or alkaline condition of the medium are the two primary environmental factors influencing microbial infestation as shown in Table IV.

Microbes as Friends

It is now well established that the microflora of the human gut are responsible for two important functions, viz.—

(a) Production of essential nutrients like vitamins and essential amino acids and

(b) detoxication of toxic materials ingested with food.

The microflora also maintain the environmental

TABLE II. *A list of common mycotoxins*

Name of toxin	Fungus	Source
Aflatoxin	*Aspergillus flavus*	Peanut, corn, grain
Ergot	*Claviceps purpurea*	Rye and forage grass
Ochratoxin A	*Aspergillus ochrocus*	Corn, beans, barley
Patulin	*Aspergillus clavat*	Apple cider
Penicillic acid	*Penicillium cylopium*	Corn, beans, barley
Sterigmetocytosin	*Aspergillus vessicolor*	Milk, wheat, cheddar, cheese
Trichothecins	*Fusarium tricintum*	Corn, grains

TABLE III. *Food borne diseases of bacterial origin*

Organism	Symptoms	Incriminated foods
Salmonella	Diarrhoea, fever after 6-48 hr.	Meat, poultry, milk, salads, egg product
Shigella	Diarrhoea, fever after 15-16 hr.	Vegetables, shell fish
Escherichia coli	Diarrhoea, fever after 6-80 hr.	Vegetables, water, cheese
V. cholerae	Diarrhoea, dessication	Water, vegetables, shell fish
V. parahaemolyticus	"	Fish, sea food
Brucella	Fever, 5-12 days	Raw milk, cheese
S. aureus	Vomiting 1-18 hr.	Meat, pastries, salads
Cl. botulinum	Neuroparalytic symptoms 6 hr.-6 days	Home canned vegetables, fish
Cl. perfringens	Diarrhoea, 9-24 hrs.	Cooked meat, poultry
B. cereus	Diarrhoea, 1-15 hr.	Cooked rice.

TABLE IV. *Environmental factors and microbial growth*

Food poisoning bacteria	Toxicogenic moulds	Environmental factors
Rapid growth 10–40°C	Rapid growth 15–40°C	Temperature
No growth below 4° and above 60°	No growth below 0° and 50°C	Temperature
Rapid growth 8.5–9.5	Rapid growth	*p*H
4.5–5.0	9.5 or <3.0	

conditions of the internal mileu of the gut optimal for normal processess of assimilation and excretion. We know that antibiotics and certain drugs used in day-to-day illnesses disturb the ecology of the microflora. The role played by the rumen flora in the nutrition of farm and domestic animals is also widely appreciated. The gut is the habitat of the commensal microflora and can be considered as part of the internal environment which profoundly affects food.

In addition to this, man has, from primitive times, learnt the art of fermentation and microbial transformation of food. Obviously he did not become aware of the exact role of microbes in such useful activities till the dawn of the science of microbiology. We have heard of the classical work of Leewenhouk, Pasteur and others. From the work of Pasteur to modern microbial technology and genetic engineering there has been dramatic progress with very significant gains to human welfare.

I would like now to draw you attention to the traditional technology used in the far East, Philippines, Indonesia and India for processing certain cereals and plant products. The *Koji* fermentation has been practised in Japan for over thousand years. It may not be an exaggeration to say that the tradition of *Koji* making led to the emergence of Japan as one of the countries foremost today in the field of fermentation. I have given in Figure I another example from Indonesia—the *Tempeh*. The nearest to this is the *Iddli* and *Dosai* of South India which have now become part of our national culinary.

Indigenous fermented food are important for a number of reasons :

(i) They are foods and food processes that have survived and persisted over the centuries in the developing world.

(ii) They are important in the nutrition of the poor, and rich alike.

(iii) They are generally of low cost and yield aromas, flavours, tastes highly acceptable to millions of people.

(iv) They reduce cooking time, often lead to improvement in the quality of the raw materials.

Take *Iddli* for example. It is product made by the mixed fermentation of rice and a legume. The ground paste or slurry is allowed to ferment overnight. Microorganisms such as *Leuconostoc mesenteroides* produce lactic acid, CO_2 and possibly vitamins and some essential amino acids like lysine, tryptophan, etc. The substrate becomes acidic and are therefore leavened. The gums present in *Urad Dal* and the dextrans produced by bacteria retain CO_2 and give the desired texture for *Iddli*. The acidity of the *Iddli* makes the product resistant to deterioration or invasion by food spoilage or food poisoning organism. *Iddli* and *Dosai* permit the incorporation of additional proteins or minerals to design a wholesome and acceptable food for our people. One need not have to conduct any market survey or acceptability trial on this product in contrast to exotic products based on imported technology such as breakfast cereals, soyabean nodules, vegetable sausages or yeast extract. It is interesting to note that most of the documented scientific work on *Iddli* has been done under the guidance of Professors Keith H Steinkarus at Cornell University Ithaca, U.S.A. although earlier some pioneering work was done at the Central Food Technological Research Institute, Mysore, Multinational concerns like the Nestles of Switzerland have set up big processing units in

Taiwan and Java to mass produce *Tempeh* (Fig 1) It is gratifying to note that stimulated by the work of CFTRI, there are some privately sponsored agencies which market *Iddli* premixes.

Food and Disease

Various conditions of liver dysfunctioning are the diseases which arise out of microbial and fungal spoilage of food articles such as paddy, wheat, sorghum, oil seeds, legumes, etc. A direct cause-effect relation between exposure to aflatoxins and liver tumours has not been demonstrated in the human although circumstantial evidence substantiates the inference that biliary cirrhosis, particularly in growing children, may be associated with fungal toxins.

Environmental diseases arising out of milk and meat are enumerated in Table V. We must also consider that a few food articles can contain natural toxicants some of which have been included in Table VI. The story of lathyrism and the bizarre aspects of its being used to pay the wages of bonded labour in Madhya Pradesh has received wide publicity of late.

TABLE V. *Diseases transmitted to man through food*

Meat	*Milk*
Zoonoses	Anthrax
Pasteurellosis	Brucellosis
Leptospirosis	Colitis
Q Fever	Foot and mouth
Foot and mouth	Toxoplasma
Trichinosis	Tuberculosis
Salmanellosis	Staphylococcosis

TABLE VI. *Natural toxicants*

Chemical	*Source*
Cyanogenic glycosides	Cassava, Almond
Hypoglycine	Soyabean
Vicine	Vicia faba
Lathyrogen	Kesari dal
Sanguinarin	Argemone oil
Tryptic inhibitors	Soyabean, pulses
Avidin	Raw eggs
Ricin	Castor seed
Gossypol	Cotton seed

In addition, many herbal teas, decoctions or traditional herbal medicines could contain very powerful toxic substances as exemplified by the pyrrolizidone alkaloids in South American herbal teas. Some of these are mentioned in Table VII.

TABLE VII *Toxicity of some herbal preparations*

Chemical	*Source*
Pyrrolizidone alkaloids	South America, Toxic to liver
Heliotropium	Afghanistan, 1600 cases of veno-occulsive death
Crotolaria	Rajasthan, 67 cases 28 dead

Environmental Factors Affecting Food

One of the main concerns today is how environmental factors influence the composition of food and more specifically lead to the possibility of food contamination. Pathways by which exogenous chemicals enter the food chain are illustrated in Fig. 2. Pollutants arise from both natural sources and industrial effluents. Fluorosis caused by fluoride in water is a natural pollution. In contrast, Mina Mata disease in Japan was caused by the consumption of fish contaminated with mercury discharged from effluents into the sea.

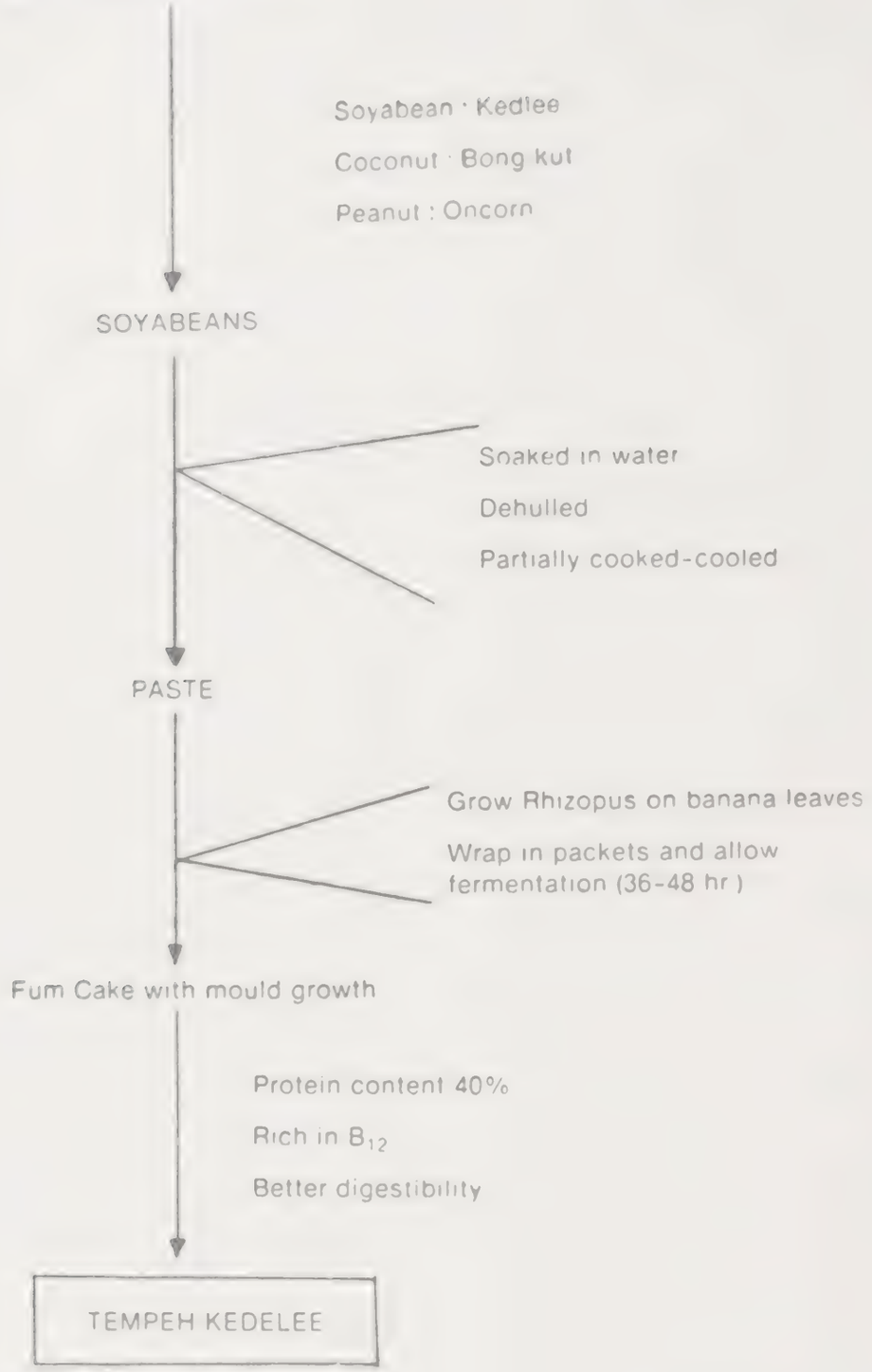
The green revolution philosophy is dependent on the twin strategy of high yielding varieties of food crops for monoculture propagation and intensive use of fertilizers and water management. The trend of use of chemical fertilizers is evident from the figures given in Table VIII. Green revolution made it possible for us to produce 130 millions tonnes of foodgrains in 1980-81. This was however at the cost of 18 million tonnes of nutrients of the soil. By the current fertilizer input practices we could replace about 10 million tonnes of the nutrients. By 2000AD at the current rate, we will be facing a situation of a deficit of 104 million tonnes of nutrients of the soil. It is doubtful whether we would be then in a position to replace them as rapidly as we exhaust them. Besides the above disastrous impact on the soil, chemical fertilizers have been shown in some studies to adversely effect the quality of food. The disturbance of calcium phosphate ratio by phosphatic fertilizers is known. The possibility of cereal crops picking up more zinc and cadmium from soil enriched with superphosphate cannot be excluded.

Pesticide Residues

The high yielding varieties used currently for food crop production are susceptible to various fungal and insect attacks. I have already mentioned the extent of losses during the post-harvest phase which has been estimated between 20-30% of the total produce. To prevent these losses and to boost farm production, use of chemical pesticides is being resorted to with great vigour. The trend of pesticide use patterns in India is shown by figures given in Table IX. Pesticides continue to be used even in situations where they have been rendered ineffective by development of resistance by the target organisms. In addition, the indiscriminate use of chemical pesticides in agriculture, has led to the emergence of resistance of the mosquitoes, the insect vector involved in the transmission of malaria and filaria.

Above all, the indiscriminate use of pesticides has precipitated a situation where practically no article of food is free from pesticide residue. The data on such residues are voluminous. I have given some representative data for cereal and vegetables for DDT in Table X. FAO/WHO panels have fixed 0.05ppm as the admissible daily intake of DDT. If we were to compute daily intakes from available Indian data, one ends up with figures ranging from 2.15ppm. Breast milk, cow's milk, buffalo's milk and infant milk products contain substantial amounts.

Fig 1 INDONESIAN TEMPEH



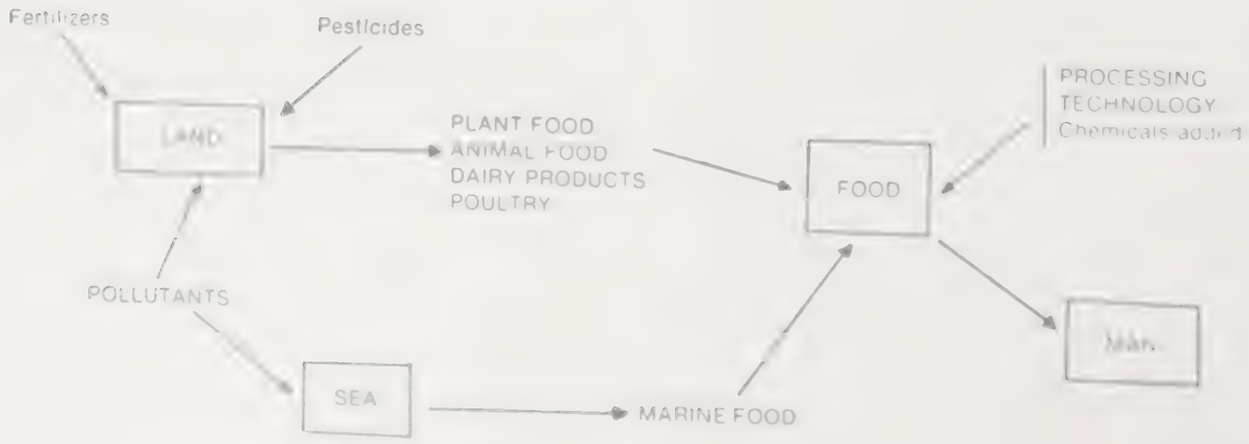


TABLE VIII *Consumption of chemical fertilizers (kg hectare cropped area)*

	1967-68		1977-78	
	N	P_2O_5	N	P_2O_5
Tamil Nadu	20.7	9.2	40.0	10.9
Punjab	14.0	3.7	54.0	17.6
Andhra Pradesh	12.5	4.0	26.0	10.1
Uttar Pradesh	8.2	2.6	28.4	6.1
Madhya Pradesh	1.3	0.4	4.9	2.4
Rajasthan	1.6	0.5	5.6	1.1
All India	7.2	2.8	17.8	5.3

TABLE IX *Pesticide usage pattern in India (Metric tonnes)*

	1973-74	1983-84
Chlorinates	32,625	65,085
Phosphates	3,570	23,000
Carbamates	2,510	6,310
Plant based compounds	50	120
Fumigants	1,150	1,325
Fungicides	10,337	12,550
Weedicides	810	2,770
Rodenticides	550	850
Ascaricides	130	220
Nematocides	25	55
Plant growth regulators	15	55
Total	51,772	1,12,340

TABLE X. *DDT content in some food (ppm)*

Wheat	1.6 - 76.0
Rice	1.0 - 16.4
Pulses	3.0 - 35.0
Groundnut	3.0 - 35.0
Vegetables	0.5 - 5.0
Potatoes	68.5

A recent report of Global Environmental Monitoring System confirms that the content of DDT residues and gammaxene in human breast

A recent report of Global Environmental Monitoring System confirms that the content of DDT residues and gammaxene in human breast milk in India and China is so high that infants would be consuming on the average 3-4 times the ADI of these toxic chemicals.

Food Additives

Modern food technology and processing of foods for mass consumption subject food to the exposure of many exogenous chemicals added as anti oxidants, colours, additives, preservatives, artificial sweetners, texture improvers, etc. The list of food additives runs to several hundreds of chemical entities. The impact of this can be seen from the example that Americans are reported to consume 1,000,000,000lbs annually of nearly 3000 food additives or on the average an American consumes 3.5lbs of these chemicals annually.

We have not reached that peak of development or life style as yet in our country. However, with more urbanization and processed foods penetrating into our rural regions we will have to co-exist with chemicals. While all care is expected to be taken by regulatory agencies to use the latest scientific knowledge while permitting the addition of these chemicals, we have to cope with extensive adulteration and lack of vigilance on the part of enforcement authorities. Adulteration of food in India is multi-dimensional and volumes can be written on the subject. I only wish to refer to the practice of using non-permitted dyes to colour savouries and sweets. We also get occasional reports of admixture of cooking oil, particularly mustard oil, with Argemone seed oil or coconut oil with 'white oil'. Problems related to food adulteration have been identified and the solutions have been suggested. What is lacking is the agency and the political will to implement the same.

Food Poisoning and Regulatory Agencies

Episodes of food poisoning occur frequently, get publicised and after the sensation is over, are forgotten. We had three major 'hooch' tragedies in the year 1981-82. There was the macabre story of hundreds of people being afflicted with epilepsy in Sitapur and Lakhimpur Kheri after consuming *Atta* dosed with organo chlorine pesticides. I have given in Table XI, some of the well documented food poisoning episodes.

TABLE XI. *Some episodes of food poisoning*

Chemical	Source	Country
Alkyl mercury	Grains	Iraq
Alkyl mercury	Pork	New Mexico
ME IS-a triglyceride	Margarine	Holland
Cobalt sulphate	Beer	Quebec
Lead salts	Beer	Nebraska
Malathion	Wheat, rice	Kerala, India
Gammaxane	Wheat flour	U.P., India
TCP	Cooking oil	Spain

In our country, we have the CCFS under the Directorate General of Health Services with a few well equipped food laboratories. However, the inspection and the implementation of the provisions of the Food Adulteration Act are left to the States. Much remains to be done to improve the working of the inspectorate, analysis and feedback systems.

The Codex Annotations under the joint auspices

of FAO WHO has done yeomen service in laying down guidelines for deriving standards and regulations. Most of the European countries use the guidelines in their legislations. India is a member of the Codex, but has not taken full advantage of the services of the Codex nor has it set up a similar national Codex for urgent natural needs.

Conclusion

In this rambling survey, I have tried to touch on some aspects of environment which have an impact on our food. Each aspect deserves to be discussed in much greater width and depth. The basic tenets of food as defined by Caraka about 2000 years ago are as relevant today as they were during his times. Our planning for food sufficiency and the evolution of a National Food Policy should not ignore traditional wisdom and also techniques of food processing handed down through generations.

Currently, environmental pollution and its effect on the quality of food is the most serious problem. This cannot be divorced from the prevalent social evil of deliberate adulteration. Chanakya in his *Arthasastra* prescribed punishment including parading the offending traders with shaven heads in the streets, public whipping and the most severe deterrent of cutting their hands. Today, we have licensed factories which turn out tinted pebbles to be mixed with dal, small scale units which colour dal with metanil yellow or turmeric with calcium chromate, mustard oil with argemone oil, *Besan* with the flour of *Kesari dal*, chilli powder with brick powder, tea and coffee powder with burnt saw dust. Above all, we have to tolerate the presence of prohibitive levels of toxic chemicals in the food articles including baby foods.

Hopefully, better implementation of the Food Adulteration Act and other regulatory procedures will improve the situation in the coming years. I cannot on this occasion plead more fervently for the emergence of a consumer movement spearheaded preferably by our women activists. The message of this has to permeate to our villages also. This movement can expose adulteration and other unethical practices and also the likely ill-effects of food fads like drinking raw milk, untreated river water considering it to be 'holy'. It can creat awareness of the inimate relationship between the quality of our environment and the wholesomeness of the food we eat to enjoy our lives.

The fifth Indian Scientific Expedition to Antarctica reached Dakshin Gangotri on December 24, 1985. Headed by a glaciologist, M M Kaul from Geological Survey of India, the team includes 24 scientists from 13 disciplines. There are 61 servicemen in the team. More than 40 organizations besides the Denfence Services are participating in the expedition.

AWARDS & HONOURS

Professor V L Chopra, FNA (Plant Geneticist) Indian Agricultural Research Institute, New Delhi has been awarded the *Padma Bhushan* on the occasion of the Republic Day (1985).

Professor R P Bambah, FNA (Mathematician), Vice Chancellor, Panjab University, Chandigarh has been selected for the Mathematical Association of India's Award for 1984

Dr N Ramanathan, FNA (Biophysicist) is the recipient of the National Award from National Research Development Corporation for his invention of the Process—XERO FINIS.

Professor S Chandrasekhar, FNA (Physicist) of the Raman Research Institute, Bangalore has been selected by the University Grants Commission for the *C V Raman Award for Research in Physical Sciences* for 1981

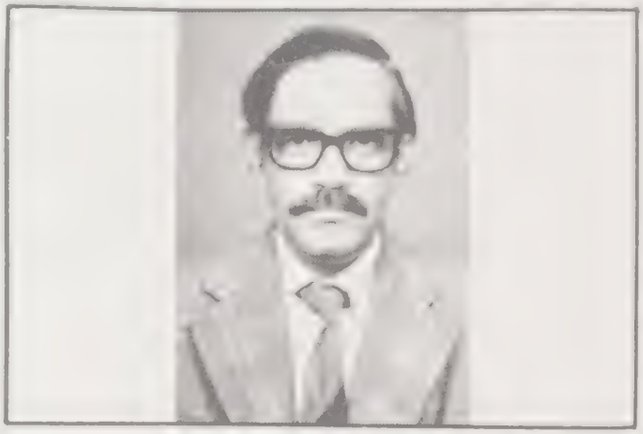
Dr B K Bachhawat, FNA (Neurochemist and Enzyme Engineer) Director, Indian Institute of Chemical Biology, Calcutta is the recipient of the *IICT Award for Life Sciences* for 1984

[illegible] Product Chemist), [illegible] selected by the [illegible] the C V [illegible] Sciences for [illegible]

Dr B Choudhury, FNA (Horticulturist), Head, Division of Vegetable Crops and Floriculture, Indian Agricultural Research Institute, New Delhi is the recipient of the *FICCI Award for Agriculture* for 1984

Dr V S Arunachalam, FNA (Physicist and Metallurgist), Scientific Adviser to *Raksha Mantri* and Secretary, Department of Defence Research and Development Organisation, New Delhi is the recipient of the *FICCI Award for Technology* for 1984

Professor K S Gill, FNA (Agriculturist), Director of Research, Punjab Agricultural University, Ludhiana is the recipient of the *FICCI Award for Agriculture* for 1984



Professor M A Viswamitra, FNA (Physicist and Molecular Biophysicist), Professor, Indian Institute of Science, Bangalore is the recipient of the *J C Bose Award* of UGC for Research in Life Sciences for 1981

Professor P N Srivastava, FNA (Radiation Physics), Chancellor, Jawaharlal Nehru University, New Delhi is the recipient of the *Meghnad Saha Award* of UGC for Research in Physical Sciences for 1982

Professor R P Rastogi, FNA (Physical Chemist), Department of Chemistry, University of Gorakhpur, Gorakhpur is the recipient of the *Meghnad Saha Award* of UGC for Research in theoretical Sciences for 1982

Professor B K Anand, FNA (Physiologist), Director, Institute of Medical Sciences, Srinagar is the recipient of the B C Roy National Award of the Medical Council of India for 1984.

Professor (Mrs) K K Rohatgi Mukherjee, FNA (Phytochemist), Professor of Chemistry, Jadavpur University, Calcutta has been elected the President of the Association International de Photobiologie (1984–88) and Chairman of the Commission on Photobiology under IUBS.

Dr B Ramamurthi, FNA, has been elected President of the World Congress of Neurosurgery from 1985 to 1989.

Professor T K Ghosh, FNA (Neurologist), University College of Medicine, Calcutta University, Calcutta has been elected a Fellow of the Asiatic Society, Calcutta.

Dr S K Jain, FNA (Botanist), Pitambar Pant National Environment Fellow, National Botanical Research Institute, Lucknow has been appointed Chairman of the Commission on Ethnobotany under the International Union of Anthropological and Ethnological Sciences.

Dr S Varadarajan [illegible] Adviser, Planning Commission, New [illegible] conferred the degree of Doctor of Science (honoris causa) by the [illegible] University, Jamaica.

ACADEMY NEWS

COUNCIL DIARY

Presidential Address at the Indian National Science Academy General Body Meeting on 1 October 1985, Delivered By Professor C N R Rao FNA, FRS

Distinguished Fellows,

It is customary for the President to say a few words on the day of the General Body Meeting, about the Academy. Sometime ago, in a Council meeting, we talked about the health of science in the country. When one looks at today's scenario, two features appear to be striking. We have a large number of scientific institutions in the country as well as a large scientific manpower; support for science has also been good in the last few years. Anyone with a good idea has been able to get decent support for his work. As one goes around the world, one gets the feeling that we in India are quite lucky with regard to research funding. When I was much younger, I used to complain that young scientists did not seem to have a place where they could argue out things or rub shoulders with the senior scientists. Today, there is increasing support to young people pursuing science and young talent is being recognized in the country in several ways. These are all the good things about the present situation.

The other part of the scenario is that we have not made many breakthroughs in science and technology; there are not as many major peaks of excellence as we would like to see. There have been discussions on this issue in many forums including in this Academy. While a lot of people carry out research and development work, most of them seem to take up safe courses and rarely take the risk of trying out problems which will eventually pay dividends but may be difficult to accomplish. Quite a bit of our research appears to be imitative. It is much easier to imitate than create one's own new lines of research

Yesterday, in this Academy, we discussed the status of higher education and research in our [illegible]. There is urgent need to do something [illegible] matter. The total scenario with respect [illegible] education in science and technology is [illegible] better institutions [illegible] education so that [illegible]

have to make science education more selective so that those who get an opportunity to pursue science as a career get better training facilities.

In about 15 to 20 years, we will be doubling our student population in science. I do not know how we will be able to tackle the situation at that time, if we do not prepare ourselves now, by making higher education selective, and by providing proper facilities at least for the most talented students. Although projects for research get funded extremely well, there is no doubt that we still have very poor infrastructure support in educational institutions. There is undue interference and pressure on educational institutions from other sources which need to be eliminated.

We need to attract the best talent for science. For this purpose, we shall have to make the scientific profession more attractive by providing the right challenges and by improving the perks and amenities for scientists. In order to get the best talent for science, several suggestions have been made including the possibility of sending some of our best young people abroad for specialized training, at our own initiative and getting them back to work here.

Whenever the Indian scientists and engineers have been challenged with an important task, they have responded satisfactorily. While we may not be at the top of the scientific world, many of us indulge in unnecessary self criticism which often goes beyond reasonable bounds. We tear ourselves apart; we become cheerless and pessimistic. This is often interpreted as a sign of weakness of the scientific community. Many people who do not belong to science are asking how it is that scientists themselves have no optimism. It may hurt us in the future if we continue to talk disparagingly about science and scientists. While it is true that everything may not be perfect, it is also true that the opportunities to do science have

stressed in the last few years. We have to do everything possible to ensure that support for science, not merely in monetary terms but also in moral terms, is not diminished. In order to get the right kind of support, I believe that we should work as a community of scientists. Although many say that there is no such thing as a scientific community in this country, we have to create such a community if we have to survive.

I believe that the Science Advisory Committee to the Cabinet (SACC) should be strengthened, wherein all important matters of scientific policy and other aspects related to science are referred to the Committee. SACC should also review the health of science periodically. I hope that in the future, the Academy would be asked by the Government to review the state of development of various areas of science. Even if the Academy is not asked to do so, the Academy on its own should take up major national issues related to science and technology and come out with reports of the kind that are worthy of the Academy. It is not necessary that such reports be totally accepted by policy makers and administrators. There is great need for such reports based on objective examination of issues.

I referred to in the morning, in the Council meeting, a report on a seemingly innocuous topic, the saccharine problem, published by the National Academy of Science, U S A. Whether saccharine should be used or not, appears a very simple problem, but it took a very thorough study conducted by a group appointed by the National Academy of Sciences to really do justice to the problem. The report prepared by an expert group is not necessarily the view of the Academy; the experts themselves may not be unanimous in their views. Yet, such an analytical report prepared by a group of scientists would be most useful. Any enlightened government would give serious consideration to the views expressed in such reports. I am personally very conscious of the fact that we have not probably done enough in this regard. We have just made a beginning in the last year or so in this direction. The Academy will have to try hard to make itself visible in the scientific scene of the country. Fellows of the Academy have to contribute their mite in making this possible.

We have had distinguished Presidents and Fellows in this Academy. Many of the Fellows and Past Presidents have been leading the country's scientific programmes. The Academy has had the advantage of having the best of minds within its orbit. It is important that people get to know what the Academy means to science in the country. I feel that we should not be shy to state the aspirations and responsibilities of the Academy.

We are trying to initiate several new activities in the Academy. One of the decisions taken recently is that we take up one or two major national issues for discussion. Yesterday we had a mini symposium on issues related to higher science and technical education. We have also initiated a programme where several lectures on frontier topics are delivered by Fellows at the time of the Council meetings. This enables a large body of the scientific community to get to know the Fellows of the Academy and their research contributions.

It is important that our young scientists get to know more about our Academy and its Fellows. There should be no generation gap in the scientific community. When I was a young person, I had opportunities to meet some of the senior scientists and policy makers. Will the present day young scientists say the same about us? How many of them know us? How many of them do we know? I get the doubt that we have not done enough to work with younger people. The Academy should think of programmes to involve young members of the scientific community. One possibility is to organise scientific conferences primarily for young scientists.

Admission of Fellows

The following scientists were formally admitted to Fellowship of the Academy. They received their scrolls and signed the Fellowship Register on 4 May 1985.

Name of the Fellow	***Introduced by***
Shri J R D Tata	Dr Raja Ramanna
Professor S Chandrasekhar	Professor S K Joshi
Dr Girjesh Govil	Dr N A Narasimham
Dr R Narasimhan	Professor B V Sreekantan
Professor B V Ramana Murthy	Professor B V Sreekantan
Professor B M Udgaonkar	Professor B V Sreekantan
Professor P K Kaw	Professor R Chidambaram
Dr B A Dasannacharya	Dr P K Iyengar
Dr S S Kapoor	Dr Raja Ramanna
Dr B L Deekshatulu	Dr V K Gaur
Professor M S Raghunathan	Professor S Raghavan
Professor V V Modi	Professor H Y Mohan Ram

The following scientists were formally admitted to Fellowship of the Academy on 2 August 1985.

Name of the Fellow	***Introduced by***
Professor P R Adiga	Professor J Barnabas
Professor G Padmanabhan	Professor J Barnabas
Dr P Balaram	Professor D P Burma
Professor Ravinder Kumar	Professor R Narasimha
Professor T R Kasturi	Professor (Mrs) Asima Chatterjee
Professor V Sasisekharan	Professor S K Joshi
Professor P M Mathews	Professor S K Joshi
Professor P T Manoharan	Professor U C Agarwala
Dr G S Ramaswamy	Professor R Narasimha
Professor M A Viswamitra	Professor D P Burma

Vacancies in the Council for 1986

Five vacancies will occur in the Council in 1986 due to the retirement of Professors T N Ananthakrishnan, D P Burma, K S Gill and K R Parthasarathy and Dr L K Doraiswamy.

Interim Vacancy in the Council for 1985

The Council appointed Dr Govind Swarup as member of Council against the interim vacancy caused by the election of Dr T N Khoshoo as Foreign Secretary. Dr Swarup will be member of the INSA Council till the next Anniversary General Meeting to be held in January 1986.

Sixth Blackett Memorial Lecture

The Council nominated Professor M G K Menon, FNA to deliver the 6th P M S Blackett Memorial Lecture at the Royal Society, London in 1986.

INSA Council met on 2-3 August 1985 and the Ordinary General Meeting was held on 2 August 1985 at the Indian Institute of Science, Bangalore. A meeting of the Coordinators of projects under Indo-Soviet Programme was held on 1 August 1985. Important decisions of the Council meeting were as follows:

1. In future, the General Madals shall be made of copper with gold plating and Subject-wise medals of copper with silver plating. All others shall continue to be bronze medals. The subject-wise medals have been reallocated to different disciplines (*Appendix 4*). With the concurrence of the donors, the scope of the *Chandra Kala Hora Medal* has been modified and this now includes 'Marine Biology' also.

2. The Council accepted the suggestion made by the Fellowship that a subject-wise medal be instituted in Atmospheric sciences to commemorate Professor K R Ramanathan, a distinguished Foundation Fellow of the Academy. The award will be made once every three years. Details regulating the medal will be formulated by the Secretaries and put up for consideration to the Council in October.

3. A discussion meeting on 'Issues relating to higher education in Science' was held on 30 September 1985. A publication entitled *Science in India: Fifty Years of the Academy** is also expected to be released on 30 September 1985 when Giani Zail Singh, President of India, will lay the foundation stone of the new Golden Jubilee building of the Academy.

4. The Council appointed 3 new members in place of outgoing members in each of the Sectional Committees for a period of 3 years with effect from 1 January 1986. The membership of the ten Sectional Committees for 1986 is given at *Appendix 5*.

INSA Nominations

Professor R P Bambah, FNA will represent the Academy on the Committee of Srinivasa Ramanujan Birth Centenary being organised by the National Board for Higher Mathematics, Tata Institute of Fundamental Research, Bombay.

Professor O Siddiqui, FNA will represent the Academy at the 41st Annual Session of the Sri Lanka Association for the Advancement of Science to be held from 9-13 December 1985 in Colombo.

Aryabhata Medal

Professor Satish Dhawan, Senior Adviser, Department of Space, recipient of the *Aryabhata Medal* (1983) of INSA delivered the medal lecture on "The application of space technology" on 2 August 1985 at the Indian Institute of Science, Bangalore. While delivering the Lecture, Professor Dhawan traced the development of space programme and the launching of the various satellites and said that the country had almost reached a stage of self-reliance in this vital field. The unstinted support of Late Shri Jawaharlal Nehru and Smt Indira Gandhi as helped the space scientists in India to put in their best to achieve the target. He said that space technology could help in better utilization of the vast natural resources of the country, e.g., introduction of satellite communications and the use of Television for mass education. He also mentioned that the first satellite in the INSAT-II series would probably be launched during early 1990.

The *Aryabhata Medal* is awarded once in every three years and the earlier recipients of the medal were Dr B P Pal and late Professor K R Ramanathan. The medal was awarded to Dr Satish Dhawan for his outstanding contributions to Space research, Aeronautical engineering and technology.

*Other reported Some notable decisions of the Council at its October meeting are as follows:

The INSA Council Officers and Members elected for 1986 are shown in *Appendix 1*.

The Academy at the Annual General Meeting held on 1 October 1985 announced the election of 30 distinguished scientists to the Fellowship of the Academy as reported on *Appendix 2*.

Appendix 3 provides the names of 6 foreign fellows elected by the Academy at the Annual General Meeting on 1 October 1985 effective from 1 January 1986.

Homi Jehangir Bhabha Medal—1984

The Homi Jehangir Bhabha Medal—1984 was presented to Professor K G Ramanathan.

Professor Ramanathan delivered the lecture entitled Ramanujan's continued fraction' on 3 May 1985 at the Bhabha Atomic Research Centre, Bombay.

Nomination to INSA Fellowship (4 May 1985)

The names of the following whose nominations have been received for consideration for election to Fellowship of the Academy since the Anniversary General Meeting of the Academy held on 2 January 1985 were read by Professor S K Joshi, Secretary.

Dr K K Sharma
Professor G S R Subbarao
Professor (Mrs) Badar Taqui Khan
Dr Subrata Ghosh
Dr G N Chowdhury

(2 August 1985)
Dr R Raghavendra Rao
Professor P S Naidu
Dr K G Nair
Professor A K Raychaudhuri

Proposal for Amendment of Rule 16(f)

The proposal for amendment of Rule 16(f) was approved.

Dr D S Bhakuni and Professor K N Mehrotra were appointed scrutineers by the President.

The amendment of rule 16(f) was declared carried having received more than 2 3rd of the valid votes polled in favour of the proposed change.

Professor N Mukunda delivered a lecture on 'Bohr and Dirac' on 2 August 1985.

Professor M A Viswamitra delivered a lecture on Physics of *Nucleic Acids* and Dr H R Krishna Murthy on strongly Interacting Fermion System on 3 August 1985.

Interim Vacancy of a Member in the Council for 1985.

The appointment of Professor Govind Swarup, FNA to fill the interim vacancy arising out of the election of Dr T N Khoshoo as Foreign Secretary was confirmed.

New Academy Awards

INSA—Dr T S Tirumurti Memorial Lectureship

The INSA Dr T S Tirumurti Memorial Lectureship has been instituted from the endowment of Rs 25,000/- made in the memory of Late Dr T S Tirumurti, Foundation Fellow of the Academy, notable for his contributions to pathology and medicine, by his daughter Mrs Janaki Ramachandran. The award will be given from the interest of the endowment, once in two years, to any scientist for his/her outstanding contribution in the field of Medical Sciences. The first Award for 1985 goes to Dr B Ramamurti, FNA, Head of the Department of Noursurgery, VHS Medical Centre, Madras. The awardee will be required to deliver lecture on the subject of his/her choice.

INSA-Vainu Bappu Memorial Award

The *INSA-Vainu Bappu Memorial Award* has been instituted from an endowment of Rs. 3 lakhs made in the memory of Late Dr Manali Kallat Vainu Bappu, Fellow of the Academy, by his mother Mrs Sunanna Bappu. The award will be made annually to any astronomer/astrophysicist of international repute. The award carries a prize of Rs 25,000 to an Indian Scientist and an amount equivalent to US $1000 if conferred to an overseas scientist. The awardee will be required to deliver lecture on the subject of his/her choice.

The first award has been made to Professor S Chandrasekhar, FNA, NL of the University of Chicago Enrico Fermi Institute for outstanding contributions to the field of astronomy and astrophysics.

Professor K Rangadhama Rao Memorial Lecture 1985

The award established in 1979 out of an endowment by the old students of the late Professor K Rangadhama Rao, an eminent physicist and a distinguished Fellow of the Academy, has been made to Professor V G Bhide, FNA, Vice-Chancellor, University of Poona, Pune.

Dr Guru Prasad Chatterjee Memorial Lecture 1985

Established in 1979 out of an endowment by Dr G P Chatterjee and Mrs Suniti Chatterjee in the memory of the Fellow who was an eminent metallurgist and a Fellow of the Academy, the award for the year 1985 has been made to Dr T N Khoshoo, FNA, Emeritus Scientist, CSIR.

Professor B D Tilak Lecture Award 1985

Established in 1982 out of an endowment by Professor B D Tilak Scientific Research and Education Trust, Pune to commemorate Professor B D Tilak, a Fellow of the Academy distinguished for his researches in the chemistry of dyestuffs and organic chemical technology, the award has been made by the Academy to Professor A K N Reddy, Chairman, Department of Industrial Management, Indian Institute of Science, Bangalore for his valuable contributions to rural development.

The following awards for 1985 were announced further:

(i) The *Srinivasa Ramanujan Medal* to Professor R Narasimha, FNA, Institute of Mathematical Sciences, Adyar, Madras.

(ii) The *Shanti Swarup Bhatnagar Medal* to Professor R Narasimha, FNA, Director, National Aeronautical Laboratory, Bangalore.

(iii) The *Professor T R Seshadri Seventieth Birthday Commemoration Medal* to Professor D K Banerjee, FNA formerly of Department of Chemistry, Indian Institute of Science, Bangalore.

(iv) The *Vishwakarma Medal* to Professor M M Sharma, FNA, Department of Chemical Technology, University of Bombay, Bombay.

INSA Senior Scientists Scheme

Under the *INSA Senior Scientists Scheme*, the following Fellows of the Academy have been awarded the Senior Scientists positions from 1 January 1986:—

1. Professor B K Bachhawat
2. Professor D P Burma
3. Professor D Nasipuri
4. Professor D D Pant
5. Professor K G Ramanathan
6. Professor S Ramanathan

The senior scientist gets a honorarium of Rs. 2500/- per month and an annual contingency of Rs. 10000/-.

INSA Bursary

The Academy has initiated a Bursary Scheme for the benefit of scientists to provide a one-time grant, urgently required for research or allied programmes which are hampered for want of small quantum of money. The grant could be used for the purchase of equipments, components, and accessories, chemicals and such other items; to organise a small group discussion of professional colleagues on important aspects of research and development; or on any other significant activity related to research. The quantum of the grant will be decided by the committee appointed by the Academy. The objective and scope of the Bursary Scheme will remain dynamic and will be suitably changed to render it more effective based on the experience gained.

Application form and other details for the Bursary grant may be obtained from the Academy.

Science and Technology Education and Future Human Needs

The International Council of Scientific Unions Committee on the Teaching of Science organised a Conference in Bangalore on Science and Technology Education and Future Human Needs during 7-14 August 1985. The conference covered topics like : Health, Food and Agriculture, Energy Resources, Use of Land, Water and Mineral Resources, Industry and Technology, Education and the Environment, Information Transfer and Technology and Ethics and Social Responsibility. The Emphasis was on the active cooperation between teachers, scientists and educators from all regions of the world in order to collect together and to disseminate such experience to stimulate new developments. The other emphasis was on interdisciplinary topics identified as essential for development. The outcome of the conference was a good get together of people who have been involved in the promotion of educational developments in the different regions of the world. A series of books will be brought out one for each of the major topics with which the conference is concerned. The books will identify aims and objectives provided relevant reviews of up-to-date subject matter including regional and national variations, identify teaching methods and materials and suggest strategies for implementation and provide help to those involved in education at different levels and in different contexts. The Indian National Science Academy hosted the conference with Professor S Chandrasekhar FNA, the Director of the Raman Research Institute in Bangalore as Head of the Local Organising Committee. The Conference was co-sponsored by COSTED, UNESCO, Raman Research Institute and several other agencies.

Olympia Prize for Dr Framji

Dr K K Framji, the Secretary-General of the International Commission of Irrigation and Drainage has been honoured with the award of the Olympia Prize 1985, which is conferred by the Alexander Onassis Public Benefit Foundation of Greece annually on individuals or institutions who have made notable contributions to the preservation of nature or the safeguarding of our cultural inheritance or scientific progress related therein. The value of the prize is US $ 100,000/- which Dr Framji is sharing with the world renowned Royal Academy of The Netherlands. Framji has made extensive contributions to the international community for over 2 decades by promoting the economic use of natural waters through scientific management to enhance the worldwide supply of food and fibre for all people. Dr Framji is of the opinion that the urgent needs of food of the developing countries in the field of water resources development should be given priority for a glib transfer of knowledge, expertise and experience in optimum management, conservation and utilisation of water resources.

INTERNATIONAL COLLABORATION

Revised Agreement with USSR Academy of Sciences

A Soviet delegation led by Academician V A Koptyug, Vice-President, USSR Academy of Sciences visited India in April 1985 to review the scientific collaboration agreement between INSA and the USSR Academy of Sciences which has been in existence for nearly a decade. The agreement was first signed in 1975 by Dr B P Pal, FNA, FRS, the then President, INSA and Academician A P Vinogradov, the then Vice-President, USSR Academy of Sciences. Academician V A Koptyug and other members of the Soviet delegation had expressed pleasure and satisfaction at the continued close collaboration between the two Academies.

Based on further discussions a revised agreement has been drawn up with 33 well-identified project areas covering disciplines of Earth, Physical, Chemical and Biological Sciences. The agreement was signed on 10 April 1985 for a period of five years (1985-90). The signing ceremony was attended by a large number of distinguished Fellows including INSA Past-Presidents, Secretaries of Scientific Departments of the Government of India and His Excellency Mr V N Rykov the USSR Ambassador to India. Professor D S Kothari, Past-President of INSA expressing his appreciation of the continued bilateral scientific Programme between India and Soviet Union stated that the aims of both the countries were to derive benefit from each other's experience and utilise science for the betterment of human life in all respects and for ensuring lasting peace. Both Professor C N R Rao, President, INSA and the USSR Ambassador spoke at the time of the signing ceremony.

Areas for Scientific Cooperation and Scientific Exchange between the Indian National Science Academy and the USSR Academy of Sciences for 1985-1990

I. Earth Sciences

1. Planetology, geochronology and evolution of the earth's crust.
2. Investigation of deep structure of the lithosphere by means of deep seismic sounding and other geophysical methods (including seismic sounding in off-shore areas).
3. Experimental mineralogy and petrology under high pressure-temperature.
4. Ore mineralogy.
5. Comparative geological studies in India and the USSR.
   (i) Comparative investigation of Stratigraphy, Absolute age, Composition, Structure and ore deposits of the ancient and precambrian of India and the USSR.
   (ii) comparative investigation of basaltic rocks (traps) of India (Deccan) and the USSR (Siberia); and
   (iii) comparative investigation of stratigraphy and palaeontology of the late proterozoic mantles of the Indian and the Siberian plattforms.
6. Basic hydrogeology.
7. Synthesis of minerals and gemology.
8. Geomagnetism.

II. Physics

1. Low temperature physics.
2. Semiconductors & Electronic materials.
3. Plasma physics—astrophysical aspects.
4. Solar, stellar and cometary & meteorite physics and cosmology.
5. Radio astronomy (Very Long Baseline Interferometry).
6. Radio science.
7. Mechanism of crystal growth and influence of defects on physical properties of crystals.

III. Mathematics

1. Mathematical statistics & probability theory.
2. Theoretical and applied mathematics.
3. Principles of application of personal computers.

IV. Chemistry

1. Organometallic chemistry.
2. Solid state chemistry and surface science.
3. Electrochemistry.
4. Chemistry of natural products.
5. Studies of inorganic materials by magnetic resonance spectroscopy.

V. Biological Sciences

1. Physico-chemical biology, including biotechnology and microbiology.
2. Cell biology and genetics, cell & tissue culture, conservation of plant.
3. Environmental protection.
   (i) mined area reclamation,
   (ii) desertification control, and
   (iii) scientific aspects of bio-farming.
4. Setting up of Indo-Soviet Biospheric Station in Western Ghats.
5. Study and protection of environment.
   (i) morphoecological feature of the mask deer with special reference to its domestication.

for obtaining musk from live animals,

(ii) investigation of behaviour and ecology of *Platanista gangetica* for developing conservation measures, and

(iii) investigation of chemocommunication of desert rodents for developing methods for agricultural pest control.

b. Neurobiology including higher nervous activity.

VI. Other Areas

1. Mass transfer including treatment of effluents from chemical industry;
2. automatization of scientific research;
3. history of science;
4. mathematical modelling of geophysical processes.

Revised Agreement with Hungarian Academy of Sciences

Recently, Professor C N R Rao, President, INSA signed a revised agreement between the Indian National Science Academy and the Hungarian Academy of Sciences for a further period of three years (1985-88). On behalf of the Hungarian Academy of Sciences, Professor Ferenc Marta, Vice President, signed the agreement. Under the revised agreement both the Academies have taken up well identified research programmes and the man-months quota has been increased from four to ten. The programme will include exchange visits of scientists for short and long durations. Young scientists will work for longer time in the laboratories/institutions of host institutes and senior scientists of each country will visit—for short term duration for attending meeting, identifying collaboration projects. The areas are listed below.

Areas for Scientific Cooperation and Scientific Exchange between the Indian National Science Academy and the Hungarian Academy of Sciences

1. Physical Sciences including Engineering

(a) Reactor physics, reactor safety, design and running of reactors, control, engineering, diagnostics

(b) Internal radiation, load, neutron, and gamma dosimetry, radioactive environment control

(c) Liquid crystal studies

(d) Solid state sciences, chemical physics including molecular structure and spectroscopy

(e) Organic chemistry

(f) Ammonia and aluminium science and technology

2. Biological Sciences including Agriculture and Medical Sciences

(a) Biochemical biology, including cytobiology, microbiology and radiation biology

(b) Structure and function of proteins

(c) Neuroscience research—basic and applied

(d) Cultivation of winter corn generation

New Collaboration with the Serbian Academy of Sciences and Arts, Yogoslavia

A new Inter Academy Exchange Programme has been signed between INSA and the Serbian Academy of Sciences and Arts and another with the Slovanian Academy of Sciences of Yogoslavia. Under these agreements three or four scientists will be exchanged between India and Yugoslavia initially, to identify areas of research for future collaboration and to establish contacts between research institutes of both the countries.

DIARY OF EVENTS

XIX General Assembly for International Astronomical Union, 19-28 November 1985 at New Delhi

Contact : Dr R M West, General Secretary, International Astronomical Union, 61 Avenue de 1' Observatorie, France, Paris.

2nd International Conference on Space Physiology, 20-22 November 1985 at Toulose (France)

Contact : Centre National D'Etudes Statiales Department des Affairs Universitaires 18, avenue Edouard Belin 31055 Toulose Cedex (France)

2nd Asian Conference on Technology for Rural Development 4-7 December 1985 at Kuala Lumpur (Malaysia)

Contact : Dr M Mohinder Singh, Organising Secretary, *Asia Tech'85*, C/o Rubber Research Institute of Malasyia P O Box 10150, Kulala Lumpur, Malaysia.

Fifth National Seminar on Physics of Semiconductors and Devices 5-7 December 1985 at Varanasi (India)

Contact : Department of Physics, Banaras Hindu University, Varanasi-221 005

International Seminar on Environment Impact Assessment of Water Resources Projects, 12-14 December, 1985 at Roorkee (India)

Contact : Dr V C Chaube, Organising Secretary, International Seminar on EIA/WRP, Water Resources Development Training Centre, University of Roorkee, India

Indian Chemical Engineering Congress 1985, 17-20 December 1985 at Calcutta (India)

Contact : Organising Secretary, 38th Annual Session, Indian Institute of Chemical Engineers, Dr. H L Roy Building, Raja S C Mullick Road, P O Box No. 1700?, Calcutta 700 032

6th International Conference on Video, Audion and Data Recording, 17-20 March 1986 at Brighton

Contact : IERE., 99 Gower St. London WC1E 6AZ, UK

International Exhibition and Conference on Electro Optics and Laser Technology, 18-20 March 1986 at Brighton

Contact: Chap and Pecse Europe Ltd., 252 Acton Lane, London W4 5DL, UK.

International Conference on Electronics in Medicine and Biology, 10 Apr. 1986 at Nottingham.

Contact: IERE, 99 Gower St, London WC1E 6AZ, UK.

Sixth International Conference on Software Engineering for Telecomm. Switching, 14-18 April 1986 at Eindhoven.

Contact: IEE, Savoy Place, London WC2R 0BL, UK.

7th International Conference on [illegible] Communications, 12-16 May 1986 at Munich.

Contact: H. Hecker, VDE-[illegible]

Exhibition: May 10-16th

Eight International Conference on [illegible] 28-31 October 1986 at Paris.

Contact: Professor D. Dutta Majumdar, Chairman, IUPRAI Electronics Communication Science Unit, Indian Statistical Institute, Calcutta-[illegible]

INSA Young Scientist Medal 1985 Awardees

Dr Vani Brahamachari (*b.* 6.6.1955) Research Officer, ICMR Centre for Advanced Research in Genetics & Cell Biology, Microbiology & Cell Biology Laboratory, Indian Institute of Science, Bangalore
—for her outstanding work on methylation of transfer RNA's and DNA

Dr Anit Dutta (*b.* 10.11.1953) Chemical Engineering Division, National Chemical Laboratory, Pune
—for his outstanding contributions to stimulation of melt spinning of polyester fibres and elucidation of stress induced migration phenomena

Dr Raghavendra Gadagkar (*b.* 28.6.1953) Centre for Ecological Sciences, Indian Institute of Science, Bangalore
—for his novel and imaginative work in providing quantitative evidence to show the existence of a behavioural caste differentiation in primitive eusocial insects

Dr K N Ganesh (*b.* 25.5.1953) Scientist, Centre for Cellular and Molecular Biology, Regional Research Laboratory Campus, Hyderabad.
—for his excellent contributions in chemical synthesis and structural studies of oligonucleotides.

Dr Sudha Jain (*b.* 2.9.1954) Medicinal Chemistry Division, Central Drugs Research Institute, Lucknow
—for her extensive contributions in the area of biosynthesis of alkaloids

Dr R L Karandikar (*b.* 1.6.1956) B-12 Indian Statistical Institute Campus, 7 SJS Sansanwal Marg, New Delhi
—for his outstanding contributions to the theory of stochastic differential equations

Dr K R Krishna (*b.* 22.9.1954) Microbiologist, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) Patancheru.
—for his outstanding work in nutrient uptake by VA mycorrhizal association with crop plants

Dr S B Ogale (*b.* 24.7.1953) Department of Physics, University of Poona, Pune
—for his outstanding work concerning conversion electron Mossbauer spectroscopic studies on alloy phase surfaces formed by ion beam mixing.

Dr T Radhakrishna (*b.* 1.7.1954) Scientist-B, Geosciences Division, Centre for Earth Science Studies, Trivandrum.
—for his paloeomagnetic studies and his contributions to geochemistry of volcanics of the suture zone between Indian and Asian continents.

Dr Arvind Rai (*b.* 2.7.1955) Deputy Assistant Director and I/C Molecular Virology and Immunology, Division of Microbiology, National Institute of Communicable diseases, 22 Sham Nath Marg, Delhi
—for his outstanding research in the fractionation of immunoreactive sub-units of *Chlamydia trachomatis* with potential for use as immuno-prophylactic agent against trachoma.

Dr (Mrs) Madhua Raka (*b.* 19.11.1953) Department of Mathematics, Panjab University, Chandigarh
- for her work settling a long standing conjecture of Watson on minima of inhomogeneous quadratic forms in several variables

Dr Ramakrishna Ramaswamy (*b.* 14.10.1953), Fellow in the Chemical Physics Group, Tata Institute of Fundamental Research, Homi Bhabha Road, Bombay
for noteworthy contributions in the field of chaos in molecular dynamics.

Dr D J Saikia (*b.* 21.1.1956), Tata Institute of Fundamental Research, Post Box 1234, Indian Institute of Science Campus, Bangalore
- for his outstanding work in the study of structure of extended radio sources

Dr Ved Pal Singh (*b.* 25.1.1953) Department of Botany, University of Delhi, Delhi
—for his commendable work in elucidating the mechanism by which aerobic spore-producing thermophilic actinomycetes thrive at high temperature

Dr G Sundararajan (*b.* 11.12.1953) Scientist 'C' Defence Metallurgical research Laboratory, P O Kanchanbagh, Hyderabad
- for his outstanding contributions to modelling solid particle erosion and analysis of high temperature creep fracture of metallic materials

Dr N Venkataramani (*b.* 20.6.1953) Plasma Physics Programme, Physical Research Laboratory, Ahmedabad
- for his studies of Alfven critical velocity phenomena and physics of scrape off layer in toroidal devices

Programme of Meetings, Lectures, Visits, Seminars, Conferences, Symposia and Workshops

Dr V K Bulatov Senior Researcher Institute of Lithosphere USSR Academy of Sciences Moscow (*Mineralogy*)	2 months from 20 October 1985	Indian Institute of Technology, Kharagpur Central Glass Ceramic Research Institute Calcutta, National Geophysical Research Institute, Hyderabad
Professor German Germanovich Tatarz Deputy Director, Institute of Metal Physics and Director of Laboratory of High Pressures, Ural Science Centre Academy of Sciences of USSR Sverdlovsk (*Materials Science*)	1 month from October 1985	National Physical Laboratory, New Delhi; Materials Science Research Centre Indian Institute of Technology, A C College of Technology, University of Madras, Madras, Indian Institute of Technology, Tata Institute of Fundamental Research, Bombay Materials Science Laboratory, Reactor Research Centre Kalpakkam.
Professor Ernst Zagidovich Kurmaev Director of Laboratory of X-Ray Spectroscopy, Institute of Metal Physics, Ural Science Centre Academy of Sciences of USSR Sverdlovsk (*Materials Science*)	1 month from October 1985	National Physical Laboratory, New Delhi; Indian Institute of Technology, A C College of Technology, University of Madras, Madras; Indian Institute of Technology, Tata Institute of Fundamental Research, Bombay Reactor Research Centre, Kalpakkam
Dr Felix Mitratanov Chief of Laboratory of Tectonics & Deputy Assistant Director of Institute of Precambrian Geology and geochronology Academy of Sciences, USSR (*Geology and Petrology*)	90 days from 1 October 1985	University of Mysore, Mysore, Osmania University, Hyderabad; Wadia Institute of Himalayan Geology, Dehra Dun
Dr Ivan Kozakov, Deputy Assistant of Chief of Lagnetism Laboratory of the USSR (*Geology*)	90 days from 1 October 1985	University of Mysore, Mysore; Osmania University, Hyderabad; Wadia Institute of Himalayan Geology, Dehra Dun.
Dr Alexandr Vasiljevich Tutukov Senior Researcher, Astronomical Council of the USSR Academy of Sciences, Moscow (*Astrophysics*)	1 month from Oct., Nov., 1985	Tata Institute of Fundamental Research, Bombay; Indian Institute of Astrophysics, Raman Research Institute, Bangalore
Dr Anatoly E Piskunov Senior Scientist at the Astronomical Council USSR Academy of Sciences, Moscow (*Astrophysics*)	1 month from Oct., Nov. 1985	Indian Institute of Astrophysics, Bangalore; Kumaun University, Nainital
Dr Yurij Aleksandrovich Faddeev Researcher, Astronomical Council of the USSR Academy of Sciences Moscow (*Astrophysics*)	1 month from Oct., Nov. 1985	Tata Institute of Fundamental Research, Bombay; Indian Institute of Astrophysics, Bangalore
Professor G W A Dick Department of Epidemology & Health Care Research University of Surrey and Chairman, Medical Advisory and Research Consultant Croydon, U K (*Yellow Fever & other Virus Diseases*)	6 weeks from 28 October 1985	Mahatma Gandhi Institute of Medical Sciences, Sevagram; National Institute of Communicable Diseases, Delhi, All India Institute of Medical Sciences, New Delhi, Haffkine Institute, Bombay Grant Medical College, Bombay; Christian Medical College Hospital, Vellore; National Board of Examination, New Delhi
Dr T D Allan Institute of Oceanographic Sciences Wormley Godalming Surrey GU8 5UB U K (*Remote Sensing*)	2 weeks in October 1985	National Institute of Oceanography, Goa
Professor Morihito Sano Department of Parasitology Hamamatsu University Hamamatsu, Japan (*Parasitology*)	50 days from 14 October 1985	University of Agricultural Sciences, Bangalore, Madras Medical College, Madras, University of Cochin, Cochin
Professor Shin Ichi Kamiyama Institute of High Speed Mechanics Tohoku University Sendai, Japan (*Magneto-aerodynamics*)	32 days from 28 October 1985	Bangalore University, Bangalore, S V Regional College of Engineering & Technology, Surat, Indian Institute of Technology, Bombay & Kanpur
Professor W L Ossowski Medical Research Centre Warsaw, Poland (*Physics, Biology, Surgery, Immunology*)	2 weeks from 1 October 1985	Postgraduate Institute of Medical Education and Research, Chandigarh Thanjavur Medical College Hospital Thanjavur

OBITUARY

In the tragic Air India Aircraft disaster over Atlantic, India lost one of its Pioneering Scientist in the field of Leather Technology on 22 June 1985. **Dr Yelavarthy Nayudamma** was born on September 10, 1922. He graduated from Banaras Hindu University, Varanasi (1942) in Industrial Chemistry and obtained his Master's and Doctor's degree from Lehigh University, USA. He played a crucial role in the establishment of Central Leather Research Institute, Madras and served as its Director from 1956-1971. He was the Director General of Council and Scientific and Industrial Research (1971-77), Vice Chancellor, JNU and CSIR distinguished Scientist at Central Leather Research Institute, Madras. He was the Fellow, Indian Academy of Sciences, National Academy of Sciences (India), Indian Standards Institution, Institution of Chemists, India (President) and Member, American Leather chemists Association and International Union of Leather Trade Chemists, Society of leather trade Chemists (UK) and COSTED (President).

Dr Nayudamma's field of specialisation is leather technology. His work includes studies on the physico-chemical properties of raw and tanned collagen; coordination complexes of chromium, aluminium and zirconium; combination tannages such as chromo-vegetable tanning; biogenesis and chemistry of vegetable tannings; mechanism of tanning, in particular protein-tanning interactions. He has done outstanding work in the field of practical application of these methods in leather technology, particularly in the better utilization if indigenous raw materials for the leather industry.

Recognising his pioneer work in Leather Technology, he was awarded the Gold Medal (1965) of M. S. University of Baroda for researches in chemistry, Padma Shri (1971), Honorary Doctorate Degree from Andhra, Sri Venkateswara, Sambalpur and Banaras Hindu Universities; Governor, International Development Research Centre (Ottawa, Canada) and Senior Adviser, U.N.

He was elected to the Fellowship of the Academy in 1975.

Baburao Shankarao Kadam, a fellow of the Academy, passed away on 24 June 1985. Born on 25 October 1903, Kadam obtained his Ph.D. degree from Cornell University in 1940. He was the Crop Botanist (1930-42); Deputy Director for Research (1942-44), Government of Bombay; Assistant Agricultural Commissioner, Government of India, New Delhi (1944-45); Director, Tobacco Research, Rajahamundry (1947-54); Director, Agriculture Research (1954-56), Saurashtra; Agricultural Extension Commissioner, New Delhi (1957-58); Joint Director, Agricultural Extension, Government of Maharashtra (1958-60); and Joint Director of Agriculture for Research and Higher Education, Maharashtra (1960-62).

Dr Kadam has developed some of the outstanding varieties of rice. Along with Dr Ramaiah, he has devised a system of nomenclature of genes in rice which is being used internationally. His contributions shed light upon the genetic relationship of black, brown and white awns in wheat for the first time. He had also developed various varieties of wheat, bajra and tobacco, etc. He had published over 100 papers on the genetics of various characters in rice, wheat, tobacco and other crops and is well-known for his pattern of anthocyanin pigments in rice, dealing with several Indian, Japanese and American cases.

In recognition of his above contributions, he was awarded Doctor of Science (honoris causa) of Mahatma Phule Agriculture University in 1982.

He was elected to the Fellowship of the Academy in 1946.

Sekharipuram Padmanabhier Venkiteshwaran was a distinguished Fellow of the Academy and a leading scientist in the field of instrumentations. He was born on 15 February 1905 and did his graduation from Palghat, specialising in Physics and Post-graduation from St. Joseph, College, Tiruchirapalli. He joined India Meterological Department as an Assistant Meterologist in 1930 and was first posted at upper Air Observatory at Agra and later at Upper Air Section at IMD, Poona. As Meterologist and Director of Instrumentations Division for more than two decades, he was responsible for the development and manufacture of a wide range of meterological and geophysical instrumentations, which were previously being imported from abroad. He also made outstanding research in cloud physics, atmospheric electricity and radiation climatology. He was responsible for the design and development of atmospheric electricity sondes for the measurement of the electric field and electrical conductivity of air and for the first ever measurement of electrical conductivity in the atmosphere using radiosondes. His two outstanding contributions during the World War II years were the preparation and publication of the Departmental memoirs on the upper wind climatology of India and the design, development and introduction of the first Indian radiosonde at a large number of stations, which was in use in India till the 1970's.

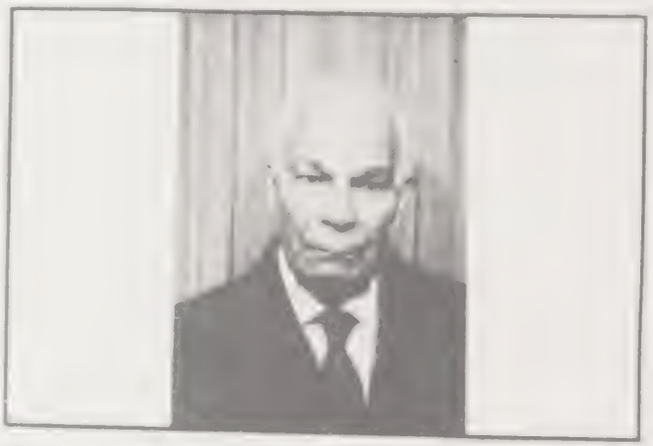
Venkiteshwaran was also responsible for the development of newly established National Aeronautical Laboratory at Bangalore and made significant contributions in using wind as an alternative source of energy. He served as Assistant Director in NAL, Bangalore. For the next 5 years he worked as Technical Adviser of Radiorefractive Index Project of TIFR at Hyderabad and was involved in the development of tethered sondes for the measurement of temperature and humidity in the lower troposphere. In recognition of his outstanding researches in these fields he was awarded Meghnath Saha Award 1972 and S K Mitra Award 1972 by the Institution of Electronics and [illegible] (India).

He was elected a Fellow of the Academy in [illegible]

Dr Rukmini Kishore Dutta Roy, a Fellow of the Academy, expired in March 1985 at the age of 82. Born on 1 March 1903, Dutta Roy received his Doctorate Degree in Engineering from Technishe Hoch. Schule, Hanover, Germany (1933) and rutired as the Deputy Director-General, Geological Survey of India. He was the General Secretary, Mining, Geological, Metalurgical Institute of India (1951-60).

Dr Dutta Roy carried out research on low and high temperature distillation on Indian Coals and on the stock and fresh coal for the utilization in the coke-ovens. His thesis on the solvent action on Indian coals clarified the fundamental difference of coking and non-coking coals. Besides, his 25 years of experience in rock and mineral analysis proved him an authority on analytical elucidation.

Dr Rukmini Kishore Dutta Roy was elected to the Fellowship of the Academy in 1948.



Professor Sri Krishna was born on 6 July 1896 and expired on 3 October 1984. He received his Ph.D. Degree from University of London and later did his D.Sc. from the same University in 1923. He was the Professor of Chemistry, Panjab University, Lahore; Biochemist, Forest Research Institute, Dehradun; Deputy Director, Council of Scientific and Industrial Research, New Delhi; and Scientific Adviser to the Indian High Commission, UK. Professor Sri Krishna was a Fellow of the Royal Society of Chemist, U.K., Member, INSA Council 1948-50 and a Government representative in 1953.

A specialist in chemistry of forest products

Professor Sri Krishna was known for synthesis of sulphur compounds in phthalsin group, survey of raw materials in India for drugs ephedrin and santonine, development of a sizing material for cotton and jute from tamarind seeds.

Professor Sri Krishna was a Foundation Fellow of the Academy.

Dr Punyabrata Bhattacharya, a Fellow of the Academy was born on 13 November 1910 and expired on 21 August 1985. He received his Ph.D. Degree from University of Edinburgh in 1938. Dr Bhattacharya was Honorary Foreign Fellow of the Italian Society of Animal Husbandry (1957); Indian Poultry science Association (President 1965-69, Patron), Indian Diary Association (President 1968-73), Patron in Chief, Indian Society of Animal Genetics and Breeding (President 1978). President, Zoology Section, Indian Science Congress Association (1958). He was the recipient of Spallanzani Medal of the International society of Animal Reproduction and Artificial Insemination.

Dr Bhattacharya was a pioneer in research on Animal Genetics and Animal Reproductive Biology in India. He was a renowned scientist in the field of Animal Husbandry. He was responsible for initiation and development of research on artificial insemination and for its introduction in the field on countrywide basis. His earlier work on the behaviour of ring chromosomes in *Drosophila melanogaster* and on control of ovulation in the cow by hormonal treatment was highly acclaimed.

Dr Bhattacharya was elected to the Fellowship of the Academy in 1956.

Dr Satya Churn Law, a Fellow of the Academy, died on 11 December 1984. He was formerly Vice-President, Calcutta Zoological Gardens and specialised in ornithology and agriculture.

Dr Satya Churn Law was elected to the Fellowship of the Academy in 1936.

Professor Ram Udar, born on 1 December 1926, died on 12 May 1985 at the age of 59. A specialist in Morpho-taxonomy of Liverworts, he was elected to Fellowship of the Academy in 1985. He was Professor of Botany, University of Lucknow.

Shri Protop Chandra Bose, born on 2 January 1900 died on 25 May 1984. He served as the Executive Engineer, Drainage in the Calcutta Corporation and was responsible for efficient and methodical working of the entire drainage system of the then Calcutta city and framed drainage projects. It is only ironical that the present-day drainage system of Calcutta may have to be revamped perhaps on the patterns of the designs of Shri Bose as the city is sinking because of ground water being drained out below Calcutta.

Shri Protop Chandra Bose was elected to the Fellowship of the Academy in 1948.

INSA LIBRARY

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Golden Jubilee Reports

A *Perspectives*

1 *Solid State Chemistry* – C N R Rao, 57 pp. Rs. 8.00 US $ 3.00
2 *Liquid Crystals* S Chandrasekhar, 19 pp. Rs 4.00, US $ 1.50
3 *Perspectives in Organometallic Chemistry* – R C Mehrotra and G Srivastava, 34 pp, Rs. 6.00, US $ 2.50
4 *The Monsoons : A Perspective* P K Das, 52 pp. Rs 7.50, US $ 2.50
5 *Basic Building Block Began (...) Big Bang (An Overview of the Physics of Elementary Particles)* – A N Mitra, 41 pp. Rs 6.00 US $ 2.00
6 *Environmental Chemical Mutagenesis* Archana Sharma, 53 pp. Rs 25.00 US $ 8.50
7 *The Dharwar Craton* C S Pichamuthu and R Srinivasan, 34 pp, Rs. 7.00 US $ 2.50
8 *Perspectives in Organic Synthesis* G Mehta and M Nagarajan, 60 pp, Rs. 7.00 US $ 2.50
9 *Mathematical Models of Environment* J N Kapur, 23 pp. Rs 5.00 US $ 2.00
10 *Genetics and Molecular Biology of Rhizobia* N K Notani, 49 pp. Rs 8.00 US $ 3.00
11 *Phylogenetics Perspectives of Protists* Shama Barnabas & John Barnabas, Rs 12.00 US $ 4.00
12 *Indian IGY Programme Achievements* A P Mitra Rs 50.00 US $ 17.00

B *Status Reports*

1 *Nutrition and Brain* Eds P N Tandon and Gomathy Gopinath, 93 pp, Rs 20.00 US $ 7.00
2 *Forty Years of Radio Science in India* A P Mitra, 26 pp, Rs 8.00 US $ 3.00
3 *Magnetism* N S Satya Murty and Madhav Rao Rs 25.00 US $ 9.00
Optical Fibres for Communication G S Sanyal and A Alphones, Rs 6.00 US $ 2.00

C *Reports of National Relevance*

1 *Rice in 2000 AD* M S Swaminathan, 22 pp, Rs 5.00 US $ 2.00

2 *Antarctica (unknown continent of unexplored wealth)*—S Z Qasim and L U Joshi, 21 pp, Rs [illegible]

3 *Indian Agriculture in 2000 AD* H K Jain, Rs 10.00 US $ 3.50

D *History of Science*

1 *Ancient Glass and India* - S N Sen and Mamata Chaudhuri, Rs 100.00 US $ 35.00

2 *Scientific and Technological Exchanges Between India and Soviet Central Asia (Medieval Period)* *Proceedings of the Seminar* during November 7-12, 1981, Bombay *Editor* B V Subbarayappa Rs [illegible] US $ 42.00

3 *History of Astronomy in India*—Ed. S N Sen and K S S Shukla, Rs 200.00 US $ 67.00

E *Other Publications*

1 *Thrust Areas in Astronomy and Astrophysics*—J C Bhattacharyya and V R Venugopal, Rs 8.00 US $ 3.00

2 *Biological Monitoring of the State of the Environment* (Proceedings of the Seminar), Rs 100.00 US $ 35.00

3 *Physics and Chemistry of Surfaces* (Proceedings of the Seminar, New Delhi 28-30 Sept 1984), Rs 200.00 US $ 67.00

4 *Science in India 50 Years of the Indian National Science Academy*—*Editors* C N R Rao and H Y Mohan Ram, Rs 125.00 US $ 42.00

Following the recommendations of the 72nd session of the Indian Science Congress Association on High Attitude Research (President: Professor A S Paintal, FNA, FRS), a 13-member task force was set up under the chairmanship of Professor Yash Pal, FNA. It has been suggested to set up a National Board for Mountain Research, Technology and Development (NBMRTD) which will function as an apex body to coordinate the R&D activities of existing agencies engaged in this field and also to set up a network of institutions with species areas of research.

APPENDIXES

Appendix 1

Officers and Members of the Council Elected for 1986

President
Professor C N R Rao (*Bangalore*)

Vice Presidents
Professor R R Daniel (*Bombay*)
Dr S Z Qasim (*Delhi*)

Treasurer
Professor P N Srivastava (*Delhi*)

Foreign Secretary
Dr T N Khoshoo (*Delhi*)

Secretaries
Professor S K Joshi (*Roorkee*)
Professor H Y Mohan Ram (*Delhi*)

Editors of Publications
Professor A N Mitra (*Delhi*)
Dr G S Venkataraman (*Delhi*)

Members
Professor U C Agarwala (*Kanpur*)
Professor J Barnabas (*Pune*)
Professor S Chandrasekhar (*Bangalore*)
Professor (Mrs) Asima Chatterjee (*Calcutta*)
Professor V L Chopra (*Delhi*)
Professor V K Gaur (*Hyderabad*)
Professor A Ghosh (*Calcutta*)
Professor N Gopinath (*Delhi*)
Professor S S Guraya (*Ludhiana*)
Dr R A Mashelkar (*Pune*)
Professor R Narasimha (*Bangalore*)
Professor M S Raghunathan (*Bombay*)
Professor V Rajaraman (*Bangalore*)
Dr P Rama Rao (*Hyderabad*)
Professor L K Ramachandran (*Hyderabad*)
Dr (Mrs) K J Ranadive (*Bombay*)
Dr Sukh Dev (*Nandesari, Baroda*)
Professor K S Valdiya (*Nainital*)

Immediate Past-President (Ex-officio)
Professor A K Sharma (*Calcutta*)

Representatives of Cooperating Academies

Asiatic Society, Calcutta
Dr A K Saha (*Calcutta*)

Indian Science Congress Association (Calcutta)
Professor (Mrs) Archana Sharma (*Calcutta*)

National Academy of Sciences, India, Allahabad
Professor K N Mehrotra (*Deoria*)

Government Representative
Professor Yash Pal (*Delhi*)

Appendix 2

Fellows elected at the Annual General Meeting held on 1st October 1985

(Effective from 1 January 1986)

DR INDER PAL ABROL, Head, Division of Soils & Agronomy, Central Soil Salinity Research Institute, Karnal
—for his outstanding contribution to an understanding of the nature and management of salt-affected non-productive soils.

PROFESSOR Y P ABROL, Nuclear Research Laboratory, Indian Agricultural Research Institute, New Delhi
—for his commendable investigations of physiological and biochemical aspects of nitrogen assimilation and utilization in crop plants.

PROFESSOR A N BHADURI, Division of Biochemistry, Department of Pharmacy, Jadavpur University, Calcutta
—for his outstanding work on the kinetic properties of UDP-galactose epimerase.

PROFESSOR A B BHATTACHARYYA, Professor & Head, Centre for Applied Research in Electronics, Indian Institute of Technology, New Delhi
—for his fundamental contributions to metal-oxide-semiconductor technology and development of microelectronics technology in India

PROFESSOR H SHARAT CHANDRA, Professor, Microbiology and Cell Biology Laboratory, Indian Institute of Science, Bangalore
—for his outstanding work on X-chromosome inactivation and mechanism of sex determination.

PROFESSOR S N CHATTERJEE, Professor & Head, Biophysics Division, Saha Institute of Nuclear Physics, Calcutta
—for his important contributions to biophysical aspects of *Vibrio cholerae* and Bacteriophages.

PROFESSOR RAMNATH COWSIK, Associate Professor, Tata Institute of Fundamental Research, Homi Bhabha Road, Bombay
—for his pioneering work in physical cosmology

DR RAJAT DE, Joint Director (Research), Indian Agricultural Research Institute, New Delhi
—for his significant contribution to dryland agriculture and foliar application of nutrients

PROFESSOR D K DUTTA MAJUMDAR, Professor & Head, Electronics and Communication Science Department, Indian Statistical Institute, Calcutta
for his original contributions to computer memory technology, speech analysis and pattern recognition

DR K GOPALAN, Scientist 'F', National Geophysical Research Institute, Hyderabad
for his pioneering contributions to geochronology, isotope geochemistry of terrestrial and lunar rocks and of meteorites

PROFESSOR P K GUPTA, Professor of Agricultural Botany, Meerut University, Meerut
—for his noteworthy contributions in the field of cytogenetics of wheat, triticales, legumes and pulses

DR V G JHINGRAN, 132, Indira Nagar Colony, Dehra Dun 248011 (U.P.)
—for his outstanding contributions to fishery biology and fish culture

DR R KRISHNAN, Group Leader, Structural Metallurgy, Metallurgy Division, Bhabha Atomic Research Centre, Bombay
—for his extensive contributions to physical metallurgy of nuclear engineering materials.

PROFESSOR V KRISHNAN, Associate Professor, Department of Inorganic & Physical Chemistry, Indian Institute of Science, Bangalore
—for his contributions to photosynthetic models and metalloporphyrins.

PROFESSOR P K MALHOTRA, Professor, Tata Institute of Fundamental Research, Homi Bhabha Road, Bombay
—for his original contributions in experimental high energy physics, particularly relating to meson resonances and quark interaction.

PROFESSOR Y S MURTY, Professor & Head, Department of Botany, Meerut University, Meerut
—for his outstanding contributions to floral morphology and anatomy of Piperales, Ericales and other groups of flowering plants.

DR S M NAQVI, Scientist, National Geophysical Research Institute, Uppal Road, Hyderabad
—for his notable contributions to geochemistry of the Precambrian rocks of South India.

PROFESSOR S P PANDYA, Director, Physical Research Laboratory, Navrangpura, Ahmedabad
—for his important contributions to nuclear structure studies.

DR R S PARODA, Director, National Bureau of Plant Resources, IARI Campus, New Delhi
—for his excellent work in the field of range management and conservation of plant genetic resources.

PROFESSOR M K K PILLAI, Professor, Department of Zoology, University of Delhi, Delhi
—for his pioneering work on insect toxicology with special reference to mosquitos.

PROFESSOR G RAJASEKARAN, Professor, Department of Theoretical Physics, University of Madras, Madras
—for his discoveries of shadow poles in multichannel scattering and his novel work on master equation on neutral current couplings.

DR A V RAMA RAO, Director, Regional Research Laboratory, Hyderabad
—for his significant contributions to total synthesis of several natural products.

PROFESSOR K J RAO, Professor, Solid State & Structural Chemistry Unit, Indian Institute of Science, Bangalore
—for his distinguished contribution to solid state chemistry of inorganic glasses.

PROFESSOR N K RAY, Professor, Department of Chemistry, Delhi University, Delhi
—for his distinguished contributions to the study of model potential for atoms and molecules and

PROFESSOR S SEN, Professor of Geology, Department of Geology, University College of Science, 35 Ballygunge Circular Road, Calcutta
—for his pioneering studies of the fabrics of the deformed rocks and magmatectonics.

PROFESSOR T N SHOREY, Associate Professor, School of Mathematics, Tata Institute of Fundamental Research, Bombay
—for his outstanding contributions to diophantine approximation and transcendence theory.

PROFESSOR M P SINGH, Professor of Mathematics, Head, Centre for Atmospheric & Fluid Sciences, Indian Institute of Technology, New Delhi
—for his contributions to perturbation techniques in ordinary differential equations, and mathematical models in physiological and atmospheric fluid mechanics.

DR C SIVARAMAN, Deputy Director & Head, Biochemistry Division, National Chemical Laboratory, Pune
—for his significant work on sub-unit interaction in the enzyme citrate lyase and its active site.

PROFESSOR R SRINIVASAN, Senior Professor & Head, Department of Crystallography, University of Madras, Madras
—for his significant contributions to the development of X-ray crystallography in India.

DR N H WADIA, Director of Neurology, Jaslok Hospital & Research Centre, Bombay
—for his outstanding research on clinical and tropical neurological problems.

Appendix 3

Foreign Fellows elected at the Annual General Meeting held on 1 October 1985
(Effective from 1 January 1986)

Academician A P Alexandrov, President, USSR Academy of Sciences, Leninsky Prospect 14, Moscow V-71 USSR

Professor R H Burris, W H Peterson Professor, Department of Biochemistry, University of Wisconsin, Madison Wisconsin, USA

Professor F A Cotton Director, Laboratory for Molecular Structure and Bonding, Department of Chemistry, Texas A & M University College Texas 77843, USA

Academician V A Koptyug, Vice President, USSR Academy of Sciences, Leninsky Prospect 14, Moscow V-71 USSR

Professor Sir Jack Lewis, Professor of Chemistry, University of Cambridge, Cambridge, UK

Dr D P Mackenzie, Reader in Tectonics, Department of Earth Sciences, Bullard Laboratories, Madingley Rise, Cambridge, UK

Appendix 4

Subjectwise Medal

The Srinivasa Ramanujan Medal
—for Mathematics or a related subject

The Satyendranath Bose Medal
—for Theoretical Physics.

The Homi Jehangir Bhabha Medal
—for Experimental Physics.

The Jagdish Chandra Bose Medal —Biochemistry, Biophysics, Molecular Biology and related areas.

The Sunder Lal Hora Medal
—for Plant and Animal Sciences.

The Darashaw Nosherwanji Wadia Medal
—for Earth Sciences (Geology, Geophysics, Geography).

The Prannba Chandra Mahalanobis Medal

The Shanti Swarup Bhatnagar Medal

The Syed Husain Zaheer Medal
—for Engineering and Technology.

The Silver Jubilee Commemoration Medal
—for Agriculture and Applied Sciences.

The Golden Jubilee Commemoration Medal
(First medal to be awarded in 1986)
—for Chemical Sciences.

The Golden Jubilee Commemoration Medal
(First medal to be awarded in 1986)
—for Biological Sciences

Endowed Medal

The Chandrakala Hora Medal
—Fisheries, Aquatic Biology and related areas.

Appendix 5

Sectional Committee—I : Mathematical Sciences

Applied Mathematics, Pure Mathematics and Statistics

Name of the Member	To serve until 31 December of
Dr V C Dumir	1986
Professor K R Parthasarathy (*Secretary & Convener*)	1986
Dr K G Ramanathan	1986
Dr O P Bhutani	1987
Professor S Ramanan	1987
Professor S K Trehan	1987
Dr R Parthasarathy	1988
Professor B L S Prakasa Rao	1988
Professor C S Seshadri	1988

Sectional Committee—II : Physics

Astronomy and Astrophysics, Physics of Materials, Space Physics, Sub-atomic, Atomic and Molecular Physics, and Theoretical Physics

Professor J C Bhattacharyya	1986
Professor S K Joshi (*Secretary & Convener*)	1986
Professor J V Narlikar	1986
Professor B Buti	1987
Professor E C G Sudarshan	1987
Dr G Venkataraman	1987
Dr R Chidambaram	1988
Dr A S Divatia	1988
Professor K P Sinha	1988

Sectional Committee—III : Chemical Sciences

Analytical, Inorganic, Physical and Theoretical Chemistry

Professor A Chakravorty (*Secretary & Convener*)	1986
Professor D V S Jain	1986
Dr S Swaminathan	1986
Professor T R Kasturi	1987
Professor P T Narasimhan	1987
Professor S S Sandhu	1987
Professor J C Ahluwalia	1988
Professor G Mehta	1988
Professor G K N Reddy	

Sectional Committee—IV : Engineering & Technology

Applied Physics, Chemical technology, Electronics and Telecommunication, Engineering and Engineering Sciences

Dr D Chakravarty	1987
Dr P Rama Rao (*Secretary & Convener*)	1986
Dr D V Singh	1986
Professor S C Dutta Roy	1987
Professor R J Garde	1987
Dr R A Mashelkar	1987
Dr B L Deekshatulu	1988
Professor Rajinder Kumar	1988
Dr P V S Rao	1988

Sectional Committee—V : Earth Sciences

Atmospheric Science, Geography, Geo-Sciences and Oceanography

Professor (Miss) Anna Mani (*Secretary & Convener*)	1986
Dr B P Radhakrishna	1986
Dr B L K Somayajulu	1986
Professor A Mookerjee	1987
Dr R G Rastogi	1987
Professor S N Sarkar	1987
Professor K Naha	1988
Professor A K Saha	1988
Professor M S Srinivasan	1988

Sectional Committee—VI : Plant Sciences

Structural, Developmental, Functional, Genetical, Ecological, Taxonomical and Evolutionary Aspects

Professor R N Kapil	1986
Professor R P Roy (*Secretary & Convener*)	1986
Prefessor S P Sen	1986
Dr D D Awasthi	1987
Dr Y S R K Sarma	1987
Professor (Mrs) Archana Sharma	1987
Professor A Gnanam	1988
Professor C P Malik	1988
Professor J S Singh	1988

Sectional Committee—VII : Animal Sciences

Structural, Developmental, Functional, Genetical, Ecological, Behavioural, Taxonomical, and Evolutionary Aspects

Professor N B K Nair (*Secretary & Convener*)	1986
Dr H D Srivastava	1986
*Professor J P Thapliyal	1986
Professor C J Dominic	1987
Dr G P Dutta	1987
Professor L S Ramaswami	1987
Professor Krishna Swarup	1988
Professor A S Mukherjee	1988
Dr V P Sharma	1988

*Appointed in place of Professor S R V Rao who has gone abroad

Sectional Committee—VIII : Medical Sciences

Basic and Clinical Medical Sciences: Anthropology, Psychology

Dr B N Dhawan	1987
Dr S Srirammachari (*Secretary & Convener*)	1987
Dr K Sundaram	1987
Professor S C Agarwal	1988
Dr D K Dastur	1988
Professor M S Valiathan	1988

Professor S R K Chopra
Professor D J Jussawalla
Dr C R R M Reddy

Sectional Committee—IX : Biochemistry and Biophysics

Biochemistry, Biophysics, Molecular Biology, Microbiology and Immunology

Dr L K Ramachandran	1986
Dr V S R Rao	1986
Dr O Siddiqi (*Secretary & Convener*)	1986
Professor G Goyal	1987
Dr V V Modi	1987
Professor M A Viswamitra	1987
Professor G Padmanaban	1988
Dr Joseph Thomas	1988
Dr S Varadarajan	1988

Sectional Committee—X : Agriculture and Forestry

Animal Husbandry, Fisheries and Forestry

Dr I S Bhatia	1986
Dr T N Khoshoo (*Secretary & Convener*)	1986
Professor P Bhattacharyya	1986
Dr K S Gill	1987
Professor S K Sinha	1987
Dr N S Subba Rao	1987
Dr P D Dogra	1988
Dr A B Joshi	1988
Professor S S Prihar	1988

Appendix 6

AGREEMENT ON SCIENTIFIC CO-OPERATION BETWEEN THE HUNGARIAN ACADEMY OF SCIENCES AND THE INDIAN NATIONAL SCIENCE ACADEMY

In the Spirit of the Agreement of scientific co-opertion between the Hungarian Academy of Sciences and the Indian National Science Academy signed on December 9, 1980 and for the further strengthening of scientific cooperation and exchanges the Academies agreed upon as follows:

Art. 1

The Academies will promote the direct contacts between scientific institutions and scientists within their purview.

Art. 2

The co-operting institutions prepare a joint plan of work, stipulating

- aims of joint research programme
- forms of co-operation
- obligations of both Academies Institutions
- programme of the research projects
- scientists responsible for the implementation of the projects

The plan of work should have the approval of both the Academies. The subjects of co-operation, as well as the institutes involved in the co-operation are enlisted in Appendix 2 of the Agreement.

Art. 3

The Academies will support the organization of joint seminars/symposia alternately held in the two countries, with the participation of 4-5 scientists from both sides on mutually accepted areas.

Art. 4

Under the bilateral agreement, the Academies will implement the exchange of scientists through.

a. *Short Study tours*: from 2 to 3 weeks, with a view to visit laboratories in the host country, to explore the new areas for joint research projects, to review the on going programme, to establish contacts, and to attend seminars/symposia.
b. *Scholarships*: from 1 to 3 months, or longer periods, with a view to work on common research projects, and to learn newer techniques, preferably, in one Institute.

Art. 5

Academies will mutually provide up to 10 man months for the study tours/scholarships mentioned under 4a and 4b. This will be subject to periodic review every alternate year.

Art. 6

The sponsoring Academy will nominate scientists proposed to be deputed to stipulated institutions, subject to concurrence of the host Academy

Art. 7

The scientist can draw up his/her own programme with the institutions of the host country, subject to the concurrence of both the Academies.

Art 8

a. The sponsoring Academy will bear the international travel expenses, whereas the host Academy will provide hospitality including local travel and other incidental expenses in connection with the programme.

b. According to the financial terms stipulated in the Annexure 1, the host Academy will provide the visiting scientists a suitable contingent grant for meeting daily expenditure on meals and incidental expenses. This should be paid to the scientist in advance. The financial terms stipulated in the Annexure shall be strictly followed by the Academies.

c. In case the scientist on study tour attends a conference symposium the registration fee will be paid by the host Academy.

d. Scientists if accompanied by their spouses, the expenses on the family member shall be met by the scientists. The Academies may provide suitable double room accommodation.

Art. 9

While nominating scientists the Academies will send essential information regarding the nominees preferably 3 months prior to the commencement of the visit. The information to be provided will include the following:

1. The category of the study visit
2. Family name, first name, scientific title
3. Place and date of brith
4. Short scientifc biography and present job
5. Special field of research
6. Significant scientific publications (not more than 6)
7. Knowledge of languages
8. Commencement and duration of stay
9. Scientific programme with details of institutes proposed to be visited and names of scientists intending to meet for discussions in conformity with the agreement concluded with the institutes of the host Academy.
10. Any other details concerned with the visit.

The host Academy will notify the sponsoring Academy of the acceptance of the assignment and of the proposals concerning the plan of work not later than two months after receiving the nomination.

The nominating Academy will send a message regarding travel details of the scientists at least 7 days before the commencement of the visit.

Art. 10

In case it becomes necessary, the host Academy will provide medical care.

Art. 11

Representatives of the two Academies will meet as and when required, but once at least every two years in order to:

—analyse the status of the programme
—discuss the extension of the forms of the co-operation
—discuss the financial conditions necessary for the implementation of the co-operation.

Art. 12

The present Agreement concluded between the Hungarian Academy of Sciences and the Indian National Science Academy comes into force on 18 July 1985 and will be valid for a period of three years.

The Academies can, at any time, make proposals for amending the Agreement or for its modification.

Signed in budapest, on 18th July 1985 in two equally authorized copies in English language.

On behalf of the
Indian National Science Academy
C N R Rao

On behalf of the
Hungarian Academy of Sciences
F Márta

Annexure to Appendix 6

Financial terms of the Agreement signed jointly by the Hungarian Academy of Sciences and by the Indian National Science Academy in Budapest, 1985

The Academies provide hospitality to the participants of study tours received under Art 4 of the Agreement, according to the following terms:

Short Study tours (2 to 3 weeks)

Accommodation

During the time of the study tour, the host Academy ensures suitable accommodation—hotel room (with bath or shower) and covers the expenses directly.

Board

to cover the cost of meals, apart from breakfast included in accommodation costs, and other expenses, the participant in the study tour receives a daily allowance of Ft 400 per day in Hungary, and Rs. 150 per day in India, paid in advance.

Scholarships (1 to 3 months)
(in Hungary)

The scholarship-holder receives free accommodation, plus a scholarship in the amount of Ft 6000 per month paid in advance, to cover the costs of meals, and other incidental expenses.

(in India)

The host Academy provides accommodation for the participant of the study tour in a guest house, or hotel, and pays the costs directly to the guest house or hotel. For meals, and other expenses the participant of the study tour receives a scholarship in the amount of Rs. 2,500 per month, paid in advance.

Travel

In both kinds of programmes travel expenses to the capital of the host country and back will be

met by the sponsoring Academy. The host Academy will provide ticket for local trips (in advance if possible) Taxi and bus fares will also be reimbursed.

Signed in Budapest, on 18 July 1985.

On behalf of the
Hungarian Academy of Sciences

F. Márta

On behalf of the
Indian National Science Academy

C N R Rao

Guidelines for Grants to Scientists Delegates Abroad by INSA under ICSU/Non-ICSU Programme

1. The Academy will contribute to the extent of Rs. 5000/- or 50 per cent of travel, per diem and registration fee or the difference between the actual expenditure and the grants received from other sources, whichever is less.
2. The per diem expenditure will be granted @ US $ 100 for Asian and African countries and US $ 120 for European Countries and Japan
3. Out of the total per diem, 40 per cent will be for cash allowance and 60 per cent for accommodation which will be paid against vouchers
4. In case the delegate is granted only 50 per cent of per diem by Academy and no other financial support is received by the delegate from other sources, the Academy may provide per diem @ US $ 50/60, depending upon the countries visited.
5. In case the delegate is granted full per diem by Academy, cash allowance equal to 40 per cent of per diem and the actual amount spent on accommodation subject to production of vouchers to a maximum of 60 per cent of per diem will be granted
6. In cases where full hospitality is provided by the organisers abroad, the Academy will grant per diem equal to 50 per cent of the cash allowance of INSA approved rates.
   All the claims will be settled and determined on the basis of the relevant documents submitted to the Academy, e.g. counterfoil of the air ticket hotel voucher, registration receipts etc.
7. Per diem will be granted for the actual number of days of the conference plus one extra day.

[illegible] Executive Secretary, INSA and printed at Kapoor Art Press, Mayapuri, New Delhi-110064

PUBLICATIONS OF THE ACADEMY

(For details please contact Associate Editor, INSA)

Proceedings

Part A (*Physical Sciences*), **Part B** (*Biological Sciences*)
First issued in 1935 as a single volume for both branches, split into two series in 1955.
Periodicity : Monthly (six issues of each part in a year)
Annual Subscription (including postage)
Inland : Rs. 120.00 (Rs. 60.00 per Part)
Foreign : £18.00 or $40.00 (£9.00 or $20.00 per Part)

Indian Journal of Pure and Applied Mathematics

Devoted primarily to original research in Pure and Applied Mathematics. First issued in January 1970
Periodicity : Quarterly up to 1971, bimonthly in 1972 and as a monthly journal from 1973.
Annual Subscription (including postage)
Rs. 250.00 (inland), £30.00 or $80.00 (foreign)
Single issue (including postage) Rs. 25.00 (inland) : £3.00 or $8.00 (foreign)

Biographical Memoirs of the Fellows of INSA

Contains memoirs on the deceased Fellows of the Academy. First issued in 1966 and priced individually. Nineth Volumes have been published so far. The tenth volume is in print.

Monographs

First issued in 1960 and priced individually.

Bulletins

Contain proceedings of the symposia. First issued in 1952 and are priced individually. The papers read at the symposium are now being published in the Proceedings also.

Popularisation of Science

Famous Plants by B. M. Johri & Sheela Srivastava. Rs. 7.50; $2.50

Year Book

A hand-book on the origin, functioning, activities, and rules & regulations of the Academy. First issued in 1960 and priced individually.

INSA Scientific Report Series

5 volumes have been published since 1978.